THE APPLICATION OF ELECTRICITY
TO RAILWAY WORKING.

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TO

RAILWAY WORKING.

BY

WILLIAM EDWARD LANGDON,

Member of the Society of Telegraph Engineers; Superintendent (Engineering Department) Post Office Telegraphs; and late Superintendent of Telegraphs on the London and South-Western Railway.

London:

MACMILLAN AND CO.

1877.

LONDON:
R. CLAY, SONS, AND TAYLOR, PRINTERS,
BREAD STREET HILL,
QUEEN VICTORIA STREET.

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INTRODUCTION.

THE application of electricity to railway working has now become of so extended and so diversified a character as to form almost a science of its own, and, as such, to lay claim to a work devoted to its purpose. Block-signalling, from having once been regarded as an obstruction to, is now the mainstay of, railway traffic; and it is not too much to say that no railway of any pretensions can conduct its traffic, with due regard to safety and despatch, without its aid.

Into railway working electricity is destined to enter far more largely than has perhaps ever been anticipated; and numerous are the ways and means by which it may be employed with profit alike to the service and the science. The character and form of instruments employed, the arrangement of circuits, the science of block-signalling, its application to junction working, station and siding protection, repetition of signals,—these are all points of interest alike to the railway

manager, to the telegraph engineer, and to the railway official generally; whilst, it is believed, they will present points of considerable interest to the general reader, and to others equally interested in railway working.

It is the object of this work to set before each and all alike—not more to the electrical engineer than to those less versed in the science, but equally interested in its application—not merely the uses to which electricity may be applied in the advancement and for the protection of railway traffic, but also the rules and principles which should regulate its practice.

Numerous as are the uses of electricity at the present day, each succeeding year, in furnishing fresh demands, produces fresh applications of it, and there is scarcely a channel of railway management or railway working in which, in its future, it is not destined to become an active agent. A scientific knowledge of its principles will become a necessity for all railway Telegraph-men; whilst even a superficial idea of its application cannot fail to be of the greatest use to others, whose duties lie more directly in the regulation of the traffic.

It must not, however, be inferred from what has been said, that it is intended this work shall be a treatise on electricity. Its province is *to render more familiar the application of electricity to the requirements of railway traffic.* With the sources of electricity, the means by which it is conveyed, or the principles which govern

its transmission from place to place, it has nothing to do. For it these are established facts, and beyond referring to them where absolutely necessary, in the most superficial manner, they will find no place in this book.

In thus marking out its path it is hoped the electrical reader will be placed at no disadvantage, whilst to the railway man, it will probably be more convenient for him to accept the fact, that the source by which the apparatus is worked exists, and that, subject to certain well-known and defined restrictions, it can be conveyed from place to place at the will of the officer whose duty it is to regulate its course.

CONTENTS.

INTRODUCTORY TERMS.

DIVISION I.

SPEAKING TELEGRAPHS.

CHAPTER I.

SIGNALLING INSTRUMENTS.

CHAPTER II.

REGULATIONS FOR SIGNALLING.

CHAPTER III.

SINGLE LINE WORKING.

CHAPTER IV.

SUPERVISION AND CIRCUIT ARRANGEMENT.

DIVISION II.

BLOCK SIGNALLING.

CHAPTER V.

HISTORICAL.

CHAPTER VI.

INSTRUMENTS AT PRESENT IN USE.

ELEMENTARY ELECTRICAL PRINCIPLES.

CHAPTER VII.

PREECE'S THREE-WIRE SYSTEM.

CHAPTER VIII.

WALKER'S SEMAPHORE SYSTEM.

CHAPTER IX.

TYERS'S SYSTEM.

CHAPTER X.

SPAGNOLETTI'S SYSTEM.

CHAPTER XI.

PREECE'S SINGLE-WIRE SYSTEM.

CHAPTER XII.

SIEMENS'S SYSTEM.

CHAPTER XIII.

BLOCK SIGNALLING.

CHAPTER XIV.

AUTOMATIC BLOCK SIGNALS.

CHAPTER XV.

JUNCTION AND SIDING WORKING.

DIVISION III.

MISCELLANEOUS APPLIANCES.

CHAPTER XVI.

SIGNAL REPEATERS.

CHAPTER XVII.

INTERLOCKING SIGNAL LEVERS.

CHAPTER XVIII.

BELLS.

CHAPTER XIX.

POINT INDICATORS, LEVEL CROSSINGS, YARD WORKING, MOVABLE BRIDGES, TRAIN DESCRIBERS.

CHAPTER XX.

LIGHTNING PROTECTORS, SWITCHES.

CHAPTER XXI.

INTERCOMMUNICATION IN TRAINS.

APPENDIX.

THE APPLICATION OF ELECTRICITY TO RAILWAY WORKING.

INTRODUCTORY TERMS.

1. **Electricity** is an agent pervading all bodies, the presence of which is rendered evident by its effects. It may be produced by friction, by motion, by heat, and it may be produced by chemical action.

2. A **voltaic Battery** is an arrangement of metals and liquids by which a *current* of electricity is produced.

3. A **Current** is the flow of electricity as it passes from one point to another.

4. For convenience in implying the **Direction of the current,** it is usual to speak of that proceeding from the copper pole of the battery as the *positive*, and that found at the zinc pole as the *negative* current.

5. All bodies are conductors of electricity. Metals conduct the best; dry air the least. Those which conduct best are termed **Conductors,** and those which conduct the least, or in other words offer very great

resistance to the passage of the current, are termed **Insulators.**

6. A **Circuit** is that means—generally, as applied to telegraphy, as the various kinds of metal wire, and the

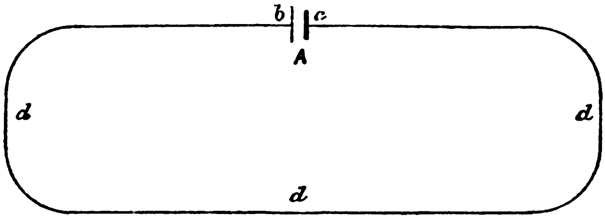


FIG. 1.

metal connections of instruments—by which the two poles, the positive and the negative, of the battery are joined together.

A (Fig. 1) is a battery, *b* is its positive or copper, *c* its negative pole, and *d* a wire,—the circuit—the means by which its poles are joined together.

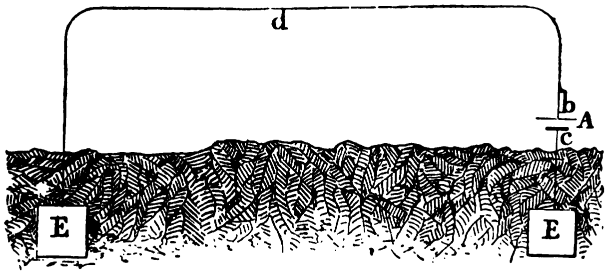


FIG. 2.

7. But the **Earth is also a conductor,** and where distance is an object the earth is made use of for

the return half of the circuit. Thus: (Fig. 2) let *A* be a battery, of which *b* is its positive or copper pole, and *c* its negative or zinc pole. Let *c* be terminated in the earth by means of a wire *d* and a metal plate *E*, and let *b* be similarly connected with a wire *d*, which let, in its turn, be also terminated in the earth by another plate, *E*. The current will traverse the conductor, *d*, as readily as though the connection between the plates *E*, *E*, were made by means of a metal.

DIVISION I.

SPEAKING TELEGRAPHS.

CHAPTER I.

SIGNALLING INSTRUMENTS.

8. **Telegraphy** is the art of conveying signals from one point to another. When the engine-driver gives his three short sharp whistles, he *telegraphs* to the guards of the train to put on their brakes. When a signalman desires an approaching train to stop, not to pass a certain point, he places his distant and home signals, for trains coming from that direction, at Danger, and by this means he telegraphs the driver of the train in question to stop at that point. But telegraphy of this kind has its limits. The whistle of the engine can be heard, and a distant signal can be seen and can be worked, only at a certain distance. Beyond the reach of the ear and the eye, electricity steps in, and supplies the want felt by the failure of such a means of communication. By its aid, letters, numerals, or sentences, can be conveyed, by certain preconcerted signals, to distant points.

9. The electric telegraph is mainly indebted for its

early success to railway companies and railway enterprise. To railways it promised, as it has since proved to be, of incalculable value. The earlier form of telegraph instrument—the *double needle*—first took root on the railway system, and there, to a great extent, it still exists. The Morse printing-instrument, the Sounder, and the Bell, systems universally adopted by the British Postal Telegraph Branch, are in the main, objects of the future to the railway telegraph service. In Ireland the Sounder is

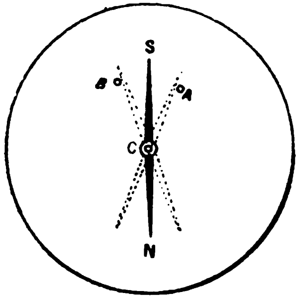


FIG. 3.

much in use, but in England and Scotland the needle is retained. The needle-instrument is undoubtedly well-fitted for railway purposes. Almost any number of them may be connected with the same wire. They are worked with but small battery power; require the least possible adjustment at the clerk's hands; seldom get out of order, and are cheaply maintained.

10. It will have been gathered from paragraph 8 that signals are of two kinds—**Visible and Audible.**

Visible signals are either *Permanent* or *Transient, recording* or *non-recording.*

Audible signals are always *transient*, and differ from each other in tone and duration.

11. The **Needle** is a **visible system,** and its signals are transient, or non-recording. Fig. 3 represents a needle *N S* pivoted at *C*, free to move as indicated by the dotted lines in the direction of the stop-pins *a* and *b*. It has thus two distinct indications; one from *S* to *b*, and back to *S;* the other from *S* to *a*, and back to *S*. These two motions can be employed, singly or com-

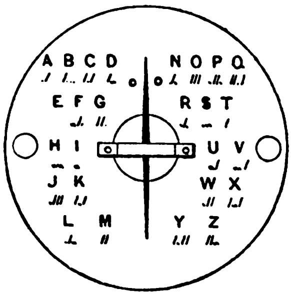


FIG. 4.

bined, to represent the letters of the alphabet, or any other preconcerted signal.

12. Either one, or two, needles and dials may be employed. Where only one is used, the instrument is termed the **single needle ;** where two are employed, the **double needle.**

13. Although the double needle claims priority, with regard to the date of its introduction, over the single needle, it may be attended with convenience if we deal with the latter first.

Fig. 4 represents the dial or face of a single-needle

instrument. The motions (§ 11) of the needle are limited by the stop-pins shown to the right and left of its upper portion. The combination or arrangement of the signals, for the representation of the letters, is such that that letter most frequently used is represented by that motion most readily produced, which involves the least

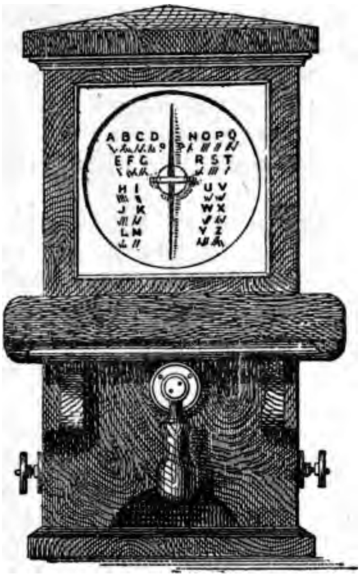


FIG. 5.

labour, and which consequently occupies the least time. Thus with *E* and *T*, the letters most frequently in use, one movement of the needle from its position of rest to *a* (Fig. 4) and back again, represents *E*, and the opposite movement *T*. The same two movements combined, that is one to the left and one to the right, form the letter *A*;

one to the right and three to the left, *B;* and one to the right, one to the left, another to the right, and another to the left, the letter C, and so on; the movements and direction of the needle corresponding to the figures representing the several letters as shown on the face of the dial.

14. The **movement of the needle on the face of the dial** is produced by that of a small magnetic needle fixed upon the same spindle to which is attached the outer needle. This magnetic needle is so arranged that it shall be free to move within two vertical coils of fine wire, in such a manner, that when the upper portion is within one coil, the lower portion shall be within the other.

15. The **movement of the inner** or **magnetic needle** is produced by the action or influence of the electric current upon it when passing through the coils, and the *direction* in which the needle moves depends upon the *direction of the current.* Thus when the current passes into an instrument by the right-hand terminal (Fig. 5), and leaves it by the left-hand terminal, the top portion of the needle (Fig. 4) is inclined to the right, forming the letter *T;* and when the current enters by the left-hand terminal, and leaves by the right-hand terminal, the opposite movement is obtained and the letter *E* is formed.

16. The direction and the duration of the current is controlled by a **Commutator** or **Key,** placed in the front of the instrument, below the dial, and under the writing desk. There are two forms of commutators for single-needle instruments, viz., the tapper or pedal form, chiefly used in the Postal Telegraph Department; and the drop handle, that mostly used on railways. The principle is the same in both. When the pedals of the former, and

the handle of the latter, are in their position of rest, the line circuit is complete through the coils of the instrument; when the right-hand tapper is depressed, or when the lower portion of the drop handle is moved to the left, the indication of the needle is to the right; whilst the opposite movement of the handle, or the depression of the left-hand tapper, produces the opposite movement of the needle.

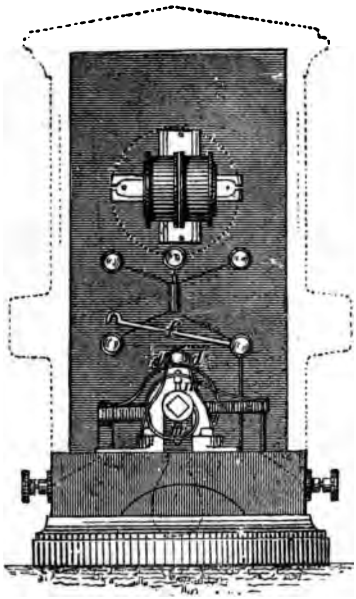


FIG. 6.

17. Figs. 6, 7, and 8 will enable us to follow out these two actions and to trace their effect. The handle by which the instrument is worked is fixed upon an arbor, *D E*, which is insulated as shown in Figs. 7 and

8, at a point midway between those letters. To either of these insulated portions of the arbor is attached a metallic projection, that at *m'* Fig. 6 extending downwards, and that at *m* upwards. *d d'*, are two steel springs in connection with the brass plates *a a'*, fixed to the base of the instrument. The tendency of these two springs is to press against a bridge-piece *f* (Figs. 6 and 8). Four terminals (*A*, *B*, *C*, *Z*) are attached to the instrument. *A* is in connection, externally, with the line wire, and internally with the right-hand coil of the instrument. *B*, externally, with the earth and, internally, with the plate *a'*. *C* with the copper pole of the battery externally, and internally by a metal spring band, or a piece of stranded

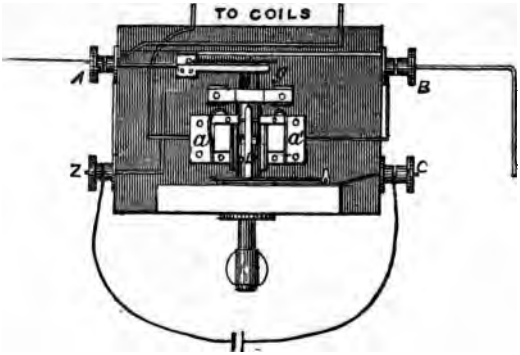


FIG. 7.

wire, with the insulated half of arbor *D*, and *Z*, externally, with the zinc pole of the battery, and internally with the other portion, *E*, of the arbor through the tweezer springs *g* seen in Figs. 7 and 8 at the extremity of the arbor *D E*, the object of which is to form metallic contact with it, and at the same time to influence the

handle, when not in use, to resume its (vertical) position of rest. *F* is a lightning protector interposed between the coils and the line wire. If now we move the handle to the left, we shall, in doing so, place the projection *m'* in contact with the brass plate *a*. At the same time the projection *m*, on the other portion of the arbor, is not only brought into contact with the spring *d'*, but also

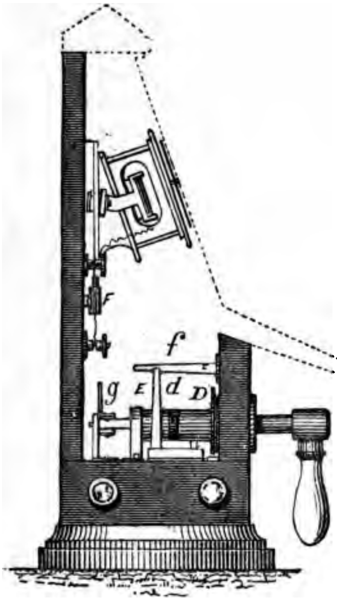


FIG. 8.

carries it away from its position of rest against the bridge *f*, the connection between which is thus broken. The battery current is now in action. That from the copper pole passes in, at the terminal *C*, to that portion of the

arbor marked *D*, and thence, by the projection *m′*, to the plate *a*, whence it passes through the coils to terminal *A*, and so out on to the line wire and to the other instruments in circuit. Precisely at the same moment the zinc pole of the battery is brought in connection with the earth, or *B* terminal of the instrument, by way of the spring at the extremity of the arbor, whence it passes to that portion of it marked *E*, and thence through the projection *m′*, to the spring *d′*, and away by the plate *a′*. In order that the current may flow it is necessary that the two projections, *m*, *m′*, should be, not only in contact with their respective parts, but that *m* should have carried the spring *d′* away from the bridge piece *f*.

But if we now reverse the motion of this handle, and instead of carrying it to the left, move it to the right, we shall completely reverse the order of the contacts. *m* will now be pressing against, and have carried away from its position of rest, the spring *d*, and *m′* will be in contact with *a′*. The zinc pole of the battery will now be in connection with the line wire by way of *E*, the spring *d*, the coils, and the terminal *A*; and the copper with the earth by way of *D*, *m′*, the plate *a′*, and the terminal B.

In the first case the current entered the coils by the right-hand terminal (Fig. 7), deflecting the needle to the right; and in the latter by the left-hand terminal, deflecting the needle towards the left. The course of the current may be regarded, in the former instance, as starting from the copper pole of the battery, through the coils of the instrument to the terminal *A*, and on to the line wire, through the instruments in circuit to the earth at the other end, and thence by the earth back to the zinc pole. In the second case we may still regard it as starting from the copper through *m′*, the plate *a′*, and the terminal *B*, to earth, along which it passes to the earth

connection at the distant end of the circuit, where it enters, passes through the instruments in circuit, and so back to the sending instrument, which it enters at *A;* thence it passes through the coils to the plate *a*, the spring *b*, the projection *m*, and so to the terminal *Z*, where the circuit is completed.

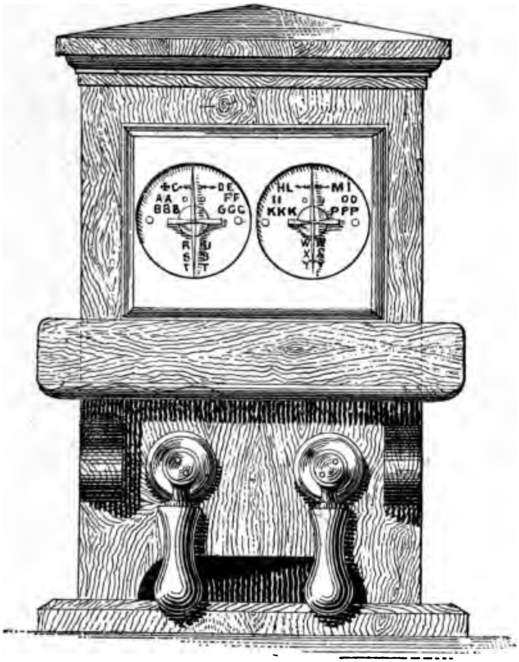


Fig. 9.

18. Duplicate this arrangement and we have the double-needle instrument.

The action of the double needle is precisely

the same as that of the single needle. The mode of working the handles, the means by which the currents are made to pass, and their action upon the needles, are identical with that described, the only difference being the duplication of the instrument and the employment of two wires instead of one. One set of batteries, however, serves the two wires, the current being divided between them when both handles are in use.

Unlike the single needle, the combination of the movements of the needles which represent the several letters of the alphabet, are not so arranged that those letters most in use shall be most readily rendered. Its letters are formed in regular succession in the direction of the first indication; thus the left-hand needle moved from its zero position in the direction of *A* (as shown in Fig. 9) twice would form the letter *A;* the movement repeated three times would form the letter *B;* one movement of the right-hand needle in the same direction once, would represent *H;* two movements *I;* three *K.* For the letters not shown above the axis of the needles, that is for *Q* and the following letters, both needles are used, their movements being made to correspond; thus for *R* the lower portion of both needles is directed once towards that letter; for *S* the movement is twice, and for *T* three times. For *W* they take the opposite direction. For the letter *C*, seen to the left of the left hand needle, the needle is carried once to the right and back to the left, thence resuming its position of rest; for *D* the movement is reversed; for *L* it is similar to that for *C* except that in this case the action rests with the right hand needle. *M* is also formed by the movement of this needle, but it is of an opposite character to that for *L.* For *U* and *V* both needles are used, the proceeding being, with regard to *U*, to first carry the lower portion

of the needles to the right and then to the left, and with regard to *V* the opposite. *Q* and *Z* are formed, the former by inclining the upper portions of the needles inwards, the latter by extending them outwards.

It will thus be seen that, ordinarily, the needles are required to take the direction of the letters as shown on the dials; that for the letters above the axis of the needles only *one* needle is used, and that the one on the dial on which the letter appears; that for the letters below their axis, both needles are worked *together;* and that the

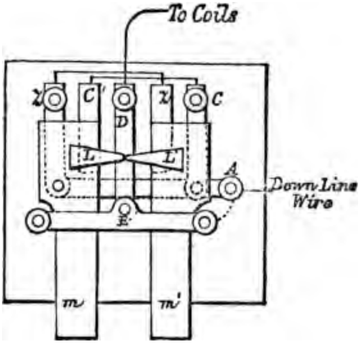


Fig. 10.

number of movements, or *beats*, which they are required to render for the respective letters are regulated by the number of times the letter is represented on the dial.

19. **The principle of the tapper or pedal commutator** is shown in Figs. 10 and 10*a*. Fig. 10 gives it in plan. *A* is a brass bar, fixed to the base board of the key, extending beneath the tappers or pedals *m*, *m'*, which are made of insulating material. These pedals

m, *m'*, are connected to the base board by two flat springs *Z*, *C'*, and *Z'*, *C*, which are connected as shown in the drawing, and are projected beneath the tappers so that, with regard to *m*, *Z* is so continued as to find its termination immediately above the plate *A*; whilst *C'* ends at a distance somewhat short of this, at which point it is brought into metal contact with a spur piece *L* fixed at right angles to the spring and projecting beyond it, so as to, when pressed down by means of the pedal piece, make contact with a fifth and central spring *D*, which, in its normal condition, rests, by the upward

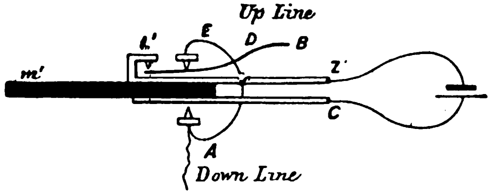


FIG. 10*a*.

tendency imparted to it, against the bridge piece *E*. The springs *Z' C*, in connection with the tapper *m'*, are arranged after a similar manner.

E is now connected with *A*. The line wires are joined, the down line usually to *A*, the spring *D* to one end of the coils, and the up line to the other end of the coils. The battery is connected up to *C* and *Z*, respectively.

If we follow out these connections in the action of the symbolical sketch, Fig. 10*a*, we shall gain some idea of the manner in which the current passes. In its position of rest the current enters, say at *A*, passes to the bridge piece *E*, thence to the spring and to the coils, by way of the

terminal in connection with *D*, and so out at *B*. When we depress the tapper *m'*, the spring *C* is brought into contact with the plate *A*, the spring *D* is carried away from the bridge piece *E* by the projection *L'*, and *L'* being in connection with the spring *Z'*, we have copper in connection with the down line wire, and zinc with the up line through the coils. The action of the tapper *m* is the same, except that as the position of the springs *Z C'*, is reversed to those in connection with *m'*, the direction of the current is reversed; so that, on its being depressed, we have zinc in communication with the up line, and copper with the down line.

CHAPTER II.

REGULATIONS FOR SIGNALLING.

20. In **signalling,** the needles should be allowed to return between each beat to the *vertical position*, a slight pause should be visible between the formation of each letter, and the completion of the word should be indicated by one beat of the left hand needle in the direction of the ✠. The mode of acknowledging the receipt of a word or signal is—

If understood, to give *E* (one beat of the left-hand needle to the right).

If not understood, ✠ (one beat of the left-hand needle to the left).

Thus *E* represents **understand,** and ✠ **not understand,** or *repeat*. With the single needle the termination of a word is indicated by a pause. "Understand," or "Not understand," is indicated by a movement similar to that in use on the double-needle system. Good readers not unfrequently receive without making use of either signal, merely indicating to the signalling station "Go on," by directing both needles to the left, thus \\ and giving the acknowledgment on the completion of the communication. The practice is not a desirable one,

and should only be permitted under exceptional circumstances, and with the concurrence of the senior officer on duty, who will be the best judge of the ability of the operator.

21. Too much care cannot be bestowed upon the **instruction of beginners or learners.** The novice should be content to advance by degrees, and to learn each step thoroughly as he or she proceeds. A hasty and impatient sender will never make a good signaller. Every beat, and every signal, should be made clearly, distinctly, and uniformly. Impatience of every kind should be checked at the outset, and under no condition allowed to pass unnoticed, whether observed in a senior or a junior. Impatience on the part of seniors, or those who have acquired experience in the manipulation of the instrument, frequently produces a nervous irritability in beginners, which clings to them ever afterwards, renders their sending hurried and indistinct, is the occasion of more errors than is generally believed, and in addition affords the worst possible example to the juniors themselves.

22. Upon speaking instruments, or instruments devoted to signalling messages, devolves much of the commercial correspondence of railway work. By their aid many of those irregularities, oversights, and errors, inseparable from a large business, scattered throughout a large tract of country, and passing through various channels, are corrected. Time is gained, confusion avoided, and pressing public demands are met. But all this can, at a minimum of cost, be secured only by a thoroughly organized system, defined rules, and careful supervision. The telegraph is for use in cases of emergency, and only in cases of emergency should it be employed.

Communications, whose end would be obtained by a letter sent by train, should follow that course, and so leave the wires free for communications which really require their service.

23. As, in order to meet the pressing demands of a large railway traffic, it is necessary to divide it into its several classes, and to work it accordingly, so is it found desirable to classify, and to give precedence and pre-eminence to certain communications which have to occupy the wires for their transmission. Thus it is desirable the telegraph branch of every railway service should be provided with a recognized list of **prefixes, indicating the order of precedence, and character,** of the communication. Priority should of course be given to that communication required for moments of the highest emergency.

24. Probably no greater emergency will be found than that in which a station has to be warned of impending danger, for instance, to a passing train so that it may be stopped on approaching that station, or, in case of accident when the road is obstructed, to warn or to stop all approaching trains. On occasions such as this, every moment, and indeed every fraction of a moment, is of the utmost importance, and the communication cannot be too brief so long as it conveys the necessary information or instruction. In like manner, the prefix should be as short and expressive of the character of the message as is possible, say for instance **DR (Danger).** Where, as in a case of this kind, the safety of many may be concerned, the communication may well dispense with code time, number of words, or even the name and station from and to. It will be sufficient for the signalling station merely to call the station required, on receiving attention

to give his own station, and then proceed with the message—as for instance,

"**DR.** Stop all (down or up) traffic."
"**DR.** Look out for runaway engine."
"**DR.** Stop (inserting the name of train) train."

This done, a more formal and explanatory message may be addressed, by the one agent to the other, confirmatory and explanatory of his former proceeding.

This prefix, of such paramount importance, should have the power of stopping *any and every communication* passing, no matter how important or in what stage, whether just commenced, in the middle, or on the point of completion; and care should be taken to impress upon every clerk and officer on the line the importance of its character. Its employment should in every case be reported, by both stations, to the General Manager, or Traffic Superintendent.

25. The next most important demand will be for a communication more complete in its form than that just dealt with. One where the emergency, although great, is not yet *so great* as that provided for under the prefix *DR.* It would be a **special service message,** and might take the prefix **SP.** Its use would be in cases of accident, stoppage of the line, movements and notices of specials. Before this prefix also, everything, except a *DR* message, must give way, whether in course of transmission or not.

26. On some lines a prefix is devoted to *signalling the departure or passing of a* **royal or other important train.** Its employment should be subject to, and under the direction and control of, the Traffic Superintendent of the line. **SPA** might be appropriate for this purpose.

27. **Single line working—crossing orders** will next lay claim to some provision. These messages are of a special character, and should come under the class *SP*, but with a further distinguishing letter. It is intended further on to devote some special remarks to crossing orders : here it will be sufficient to mention, that messages coming under this head must be of two kinds—one, an order to stop the train proceeding in one direction, and the other, an order to send forward that travelling in the opposite direction. Two prefixes are required, and, for reasons which will become evident hereafter, it may be desirable to allot to them the letters **SPR**, and **SPG**.

These prefixes also, affecting the safety of the traffic of the line, should take precedence of everything passing, with the exception of *DR*, *SP*, and *SPA*.

28. It not unfrequently happens that the Telegraph Engineer requires, or has important communications to make which suggest the propriety of affording such the next position. **DS** has for many years been the recognised prefix for communications of this character. It should only be employed under urgent circumstances, and under the direction of the Engineering Officer.

29. It is very necessary, especially in single line working, that the running of certain trains should be reported from certain points to the District Superintendent. By this means he is enabled, in the case of single lines, to consider and arrange beforehand his crossing orders; and in other cases to decide on starting, or keeping back, trains ordinarily working in connection with that whose running has to be reported. **TA—Train arrival** or **Train signal**—is generally used for this purpose It should take precedence after *DS*.

30. *Another demand* yet arises before we come to the

ordinary message work. There will be a class of messages, of no special, but rather of a very general character, which may still come under the term **On urgent service.** **SG** when sent direct to the station to which it is addressed, and **XG** when sent to another station for transmission beyond it, is the prefix usually employed; and its application will for the most part be in reference to telegraph work, as, for instance, when it is found necessary to ask for a repetition of a message, the correctness of which appears doubtful. Such a prefix, having reference to messages already transmitted, should naturally have precedence of the ordinary traffic.

31. The **ordinary traffic messages** now take their turn. **DB** for messages sent direct to a station for delivery, and **DL** for messages for transmission, have been the recognised prefixes for this character of message for years.

This completes the order of prefixes. It is possible that under special circumstances others may be found necessary, but where such is the case, their position should be clearly defined in the code of regulations for any service by which it may be adopted.

The number of words in all messages, with the exception of those bearing the prefix *DR*, should be counted, and signalled, in order that the receiving office may be able to check its correctness in this respect.

32. All ordinary traffic messages should carry a **Code time** immediately after the prefix. The code time is obtained by appropriating the letters *A* to *M* (not including *J*) to the hour sections on the face of a clock; and the letters *R*, *S*, *W*, *X*, to the minute sections between these, as shown in Fig. 11. The "code time" of a telegram will thus consist of from one to three letters, *viz.*, *one* for the hour, and, where necessary, one

or two others for the minutes. 2 o'clock would be represented by *B*, 2.45 by *BI*, and 7.12—the time shown in Fig. 11—by *GBS*, that is, *G* for 7h., *B* for 10m., and *S* for 2m. The code-time is the time at which a

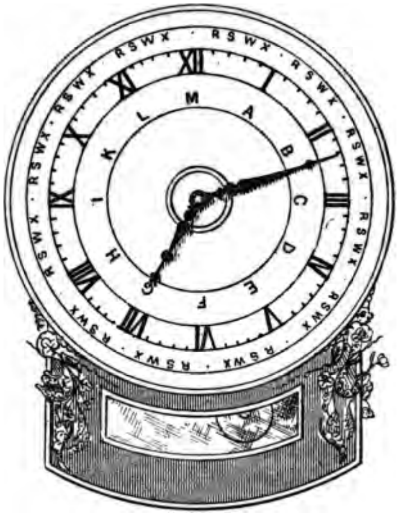


FIG. 11.

message is handed in to the telegraph office for transmission, and its use secures the transmission of messages in the order in which they have been handed in, no matter at what office.

Thus the ordinary message consists of prefix, code-time, number of words, and the written subject; as for example—

Prefix________Code Time________No. of Words________

Station from which the Message is received.	Receipt. Fin.	Receiving Clerk's Signature.	Station to which the Message is transmitted.	Time transmitted. Fin.	Transmitting Clerk's Signature or Messenger's Name.
	h. m. ,, —.n.			h. m. ,,	

________________*Station*________________187

*From*________________ *To*________________

________________*Station.* ________________*Station.*

____

____

H. M.
Received at ,, m. Signature________________

The person to whom this telegram is delivered is requested to fill in the time at which it is received, and to sign it.

33. All telegraph stations have a distinctive **code or call signal.** Thus, Aberdeen may be represented by *AB;* Cardiff by *CF*, and so forth. The message having been prepared for transmission, the code of the station required is steadily repeated with a slight pause between, as *AB—AB—AB*, until *AB*, or whoever is called, answers by holding over the needle until it is observed to be still, and then giving the call signal once. The sending station now signals its own code,

which is repeated by the station called, and the message is then proceeded with. First comes the prefix, then the code-time, number of words, name and address from and to, and then the contents of the message. The receiving office should then read over, and count the number of words. Satisfied as to its correctness he acknowledges its completion by the understand (*E*) signal, or by giving "*gd*," when the transaction is complete.

Station calls should be clearly and slowly rendered. Rapid calling is not so readily recognized, and hence less successful in procuring attention.

34. **All telegrams should be written** on forms provided for that purpose, and **signed by the sender.** Where the proper form is not to be had, the message should still be written on paper and duly signed. Messages sent under verbal instructions give rise to error and confusion, and prevent localization.

Care should be observed to write all messages in a *clear and legible manner. Abbreviations* are undesirable. The clearest and briefest language should be employed.

35. All **conversation** on the instrument, and **frivolous** or **unnecessary messages** should be strictly forbidden.

36. At many railway stations the telegraph duties are not unfrequently combined with others, so that occasions may arise when the telegraphist is unable to attend to a call. It is obvious if he were to allow the call to continue he might be depriving others of the use of the wire. To meet this a code **MQ—"wait, engaged"**—is made use of. The station called should answer the call, ascertain whom it is calling, and the nature of the message, with its code time, before giving **MQ.** No *MQ should* be accepted for a longer period than ten

minutes. If it is not relieved by that time, the station should be called again.

37. **Inattention** will be found to exist on every system to a greater or less extent. The necessity of a prompt response to every call cannot be too strongly impressed upon the staff generally. To occupy a circuit by continuous calling for a period of some thirty or forty minutes is to greatly prejudice any other work which may be waiting its turn. Where inattention from any cause arises, it may be found convenient, when the circuit is required for other purposes, to call only for periods of ten minutes, allowing an interval of a similar duration for the despatch of other messages.

38. **Wrangling and quarrelling** for the possession of the circuit should be suppressed. To obtain possession of a circuit, it is merely necessary for the office requiring it, to hold over the needle or needles—that is, supposing some other station is being called—until attention has been secured, and then to give the prefix, if it is one taking precedence, or the code time of the message. If it should be of an earlier date than that having possession of the circuit, the circuit should be given up to it. But such interruptions on a busy circuit are most undesirable, and are to be avoided by *watching* the circuit and only seeking possession of it when a later code is offered.

39. A **message** should be **regarded as commenced** when its prefix, code-time, and number of words, have been signalled, and it should not then be interrupted except by a *DR* or *SP* message.

40. Care should be taken to see that the instrument is disengaged before taking possession of it. For this purpose it is desirable, before commencing to call a station, *to give the "not understand"* signal two or three times

Should a message be in the midst of transmission, the word last signalled will be repeated, and it will thus be seen that the circuit is engaged.

41. Every instrument should be examined and the condition of the signals tested with, and reported to, its chief transmitting office every morning at the time the office is recognized as open for business.

When the communication is interrupted, the apparatus should be carefully examined, in order to see if any derangement exists which it may be in the power of the officer on duty to rectify. The instrument should be put on short circuit and the handles moved. If the needle does not respond, the fault is probably in the sending portion of the instrument, and may be found in the batteries, or wires connecting them with it. To prove if it is in the receiving portion of the instrument, remove the battery wires and apply them to the *AB* and *CD* terminals of the double needle respectively; or to the *AB* terminals of the single needle. This should pass a current through the coil under examination, and thereby produce a deflection of the needle to one or the other side of the dial. The presence of this deflection proves the correctness of the receiving portion of the instrument.

The *double needle* instrument is put on *short circuit* by joining the middle to the back terminal on either side of the instrument. The *single needle* by joining the terminals *A* and *B* (Fig. 7).

Nothing should be allowed to rest against the handle of the instrument, and no one should be allowed to touch it except the responsible officer. Care should be taken to leave, and to keep, the handles in the vertical position, [illegible]ere the tapper form is in use, to leave them free [illegible] to their normal position. Nothing should be [illegible] upon the terminals of the instrument; it is a con-

venient place for pens or pencils, and metal pens have not unfrequently, by being so placed, brought the coil wires into contact and so cut the instrument out of circuit. To avoid all possibility of interruption from this cause, or the breakage or disconnection of wires from dusting or other causes, the wires, both line and battery are sometimes brought up through the base-board of the instrument and are by this means inclosed within its case. The practice, although convenient for this purpose, is inconvenient when requiring to test the wires or apparatus, and it is questionable if it is attended with any great advantage.

42. **Batteries** should be kept in a dry place and free from books, papers, and rubbish. It is desirable to give them some protection—a cupboard or a covering of some description—so that the wires and battery cells may not become broken.

43. The free circulation of "**Time**" once a day is necessary to the due regulation of every system. It is usually sent at 10 A.M. by arrangement with the Postal Telegraph Department under which a current, known as the "*Time current*" is signalled, direct from Greenwich, to such offices as it is thought necessary to provide for in this way. From these offices it is distributed to all telegraph stations in the following manner:—

At three minutes before ten the terminal or transmitting station calls the attention of all other stations on the circuit, or, on each circuit radiating from that office, by moving the needle or needles backwards and forwards several times, and then signalling slowly and distinctly "time." All work should then cease (unless the circuit be required for *DR* or *SP* purposes), and the terminal station will hold over—if it be a double needle—the ✠ *E*, or left hand needle to ✠, and the office at the other extremity of the circuit the *HN*, or right hand needle, to F

On the receipt of the Greenwich "Time signal," the terminal or transmitting station, on the instant, carries the ✠ *E* needle over to *E*, and the station at the other extremity of the circuit should on observing this also carry the *HN* needle over to *N*. The movement of the ✠ *E* needle, from ✠ to *E*, is the ten o'clock signal and all clocks should at once be corrected by it. With single needle circuits the entire duty devolves upon the terminal or transmitting office, but the action is the same, the needle is held over to the left as an indication that "time" is being signalled, and its movement to the right-hand side is the "time" signal.

Occasionally the time signal is not received. When this is so, the needle should not be carried over to the right, but in the place of it, the signal, "no current," should be rendered.

44. Not only is it desirable that station clocks should be kept regulated by the daily time signal, but also that the clocks of all signal boxes should in a like manner be set to it. At stations there is no difficulty in this, but at outstanding signal-boxes it is not so easily effected. Still it may be arranged by a preconcerted signal—a given number of strokes on the bell as a warning that "time" is to follow, succeeded by one stroke, which should be sent at the moment of time required to be signalled.

CHAPTER III.

SINGLE LINE WORKING.

45. No more important duty devolves upon the speaking telegraph than that required of it for the regulation of traffic on single lines of railway. Here it is invaluable, and without its aid whenever a train gets out of course delay must arise, sufficient perhaps to derange the entire service for hours. The working of single lines is one of the most onerous duties imposed upon a railway officer, and this increases with every increase of traffic, and in every case in which it becomes in the least out of course. These remarks are *not* applicable to sections of line worked by the *Train Staff, for where the traffic is governed by it, delay is at times inevitable.* With a telegraph service properly regulated, carefully administered, and efficiently supervised, not only need no danger exist, but delay may be reduced to a minimum.

46. The running of all regular trains, with their appointed crossing places, is usually set forth in the monthly service time tables; the running of all prearranged special traffic in the weekly working sheets; but where specials are required at so short a notice as to preclude the issue of printed notices, then written orders as to the crossing points, and other particulars, should, where time and means will admit, be sent forward and

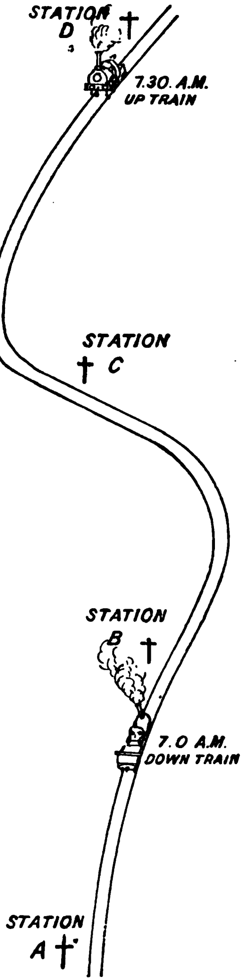


FIG. 12.

delivered personally by a *responsible officer* to every *agent or his representative*, on the single line section. Failing this, recourse must be had to the telegraph.

47. Dealing first with **the crossing of trains, the running of which have been set down in the printed service sheets or time tables:—**

It is very desirable that the running of all trains should be reported to the superintendent of the line from certain points selected by that officer, in order that he may be kept acquainted with their movements, and be prepared in good time to rearrange their crossing points should they get out of order.

Take now the following example :—

Let *A*, *B*, *C*, *D*, be a section of line with stations as indicated by the letters. Let it be assumed that at each station there is proper crossing convenience. Two trains proceeding in opposite directions are upon it, viz., the 7.0 A.M. down and 7.30 A.M. up train,

and they are timed to cross each other ordinarily at *B*, but the up train is sufficiently behind time to admit of the down train proceeding to *C*. It is evident that delay will ensue to the 7.0 down train if it is kept at *B* for the arrival of the 7.30 up, and that this will be greatly reduced if it is sent on to *C* to cross the latter there.

48. To effect this we must first arrange for *holding the* 7.30 *up at C for the arrival of the down train there*, and **not until this has been done** must the down train be ordered forward. All this should be done in the surest manner possible, with perfect order and regularity, and under a preconcerted system.

The following system is one which has stood the test of a number of years working with great success.[1]

49. Each station is provided with specially provised message forms, applicable solely to crossing trains. These forms are made up into pads, of which each station is supplied with four kinds. Two of these are composed of red and white forms arranged alternately; the other two being composed of green and white forms similarly arranged. One of the red pads is headed "Order for train not to proceed on journey," and is used only for the receipt of messages of that character. On the back of the red form, on which the message as received from the instrument is written, is a printed form headed "*Special Order to Engineman and Guard* NOT *to proceed on journey*," which has to be filled in, subject to the contents of the message, and signed by the station agent.

50. The other red pad is for the station-master's reply, and bears no endorsement to the engine-driver and guard.

51. One of the green pads consists of forms headed

[1] In the Appendix will also be found specimens of forms employed for crossing purposes by the Midland Great Western Railway of Ireland.

"*Order for train* TO PROCEED *on journey*," and bears on the back of each green leaf an endorsement headed "*Special Order to Engineman and Guard* TO PROCEED *on journey*," which has similarly to be filled up, subject to the contents of the message, and signed by the station agent.

52. The other green pad consists of similar forms, but with the heading "Agent's Reply," and without the special order on the back.

Specimens of these forms are given in the Appendix.

53. Now it will be borne in mind that the first proceeding is to stop the 7.30 up train at *C*, and the next proceeding to bring the 7.0 down train on to *C*. Two operations of a distinct character are involved. Two distinct characters of forms have been provided, the one red, the other green. Two distinctive prefixes to indicate the character of the message to be sent are needed. Let us take **SPR** for that applying to the red forms, and **SPG** for that applying to the green forms. *SPR* will consequently represent the prefix for orders *not to proceed*, and *SPG* for orders *to proceed*.

54. The crossing agent will first telegraph *C*—

> **SPR**—"Keep 7.30 A.M. up train from——— at *C* till 7.0 A.M. down train from ——— has arrived at *C*."

The clerk at *C* repeats this back to the office from whence it originated, and then, having filled in the time, date, &c., and signed it, hands it to the agent.

The agent at *C* has now to arrange for stopping the up train. His first duty is *to see* that the up signals—*home* and *distant*—are put on for this purpose. This done, he acknowledges the receipt of the order in the following terms :—

SPR.—"I will keep 7.30 A.M. up train from ——— at *C* till 7.0 A.M. down train from ——— has arrived at *C*."

55. He then fills up and signs, in ink, the form headed "Order to Engineman and Guard NOT to proceed on journey," and on the arrival of the 7.30 up train he has to show the same (with the telegram on the reverse) to the guard, and when he (the guard) has read it, he should hand it to the engine-driver and both should attend to it.

56. In the meanwhile the crossing agent *on the receipt of the reply "I will keep," &c.*, from *C*, has telegraphed Station *B*—

SPG.—"Send 7.0 A.M. down train from ——— on to *C* to pass 7.30 A.M. up train from ——— at *C*."

which has in like manner to be repeated by the clerk at *C*, and handed to the agent, who replies—

SPG.—"I will send 7.0 A.M. down train from ——— on to *C* to pass 7.30 A.M. up train from ——— at *C*."

57. The agent then fills in and signs, in ink, the green form headed "Special Order to Engineman and Guard to proceed on journey," which order he shows, with the telegram on the reverse, to the guard of the 7.0 down train, and when the guard has read it, passes it to the engine-driver, and it is to them a sufficient authority to proceed accordingly.

58. The trains having crossed at *C*, the agent there advises the crossing agent by

TA.—"7.0 down and 7.30 up trains crossed at *C* at ——" (specifying the time).

and the transaction is then complete.

59. We now come to the working of **specials for which no provision has been made in the printed time tables or service sheets.**

The running of any such train, its crossing points, &c., should be arranged *before* it is allowed to start. Every station on the line should be advised of its running, and all crossing stations duly instructed. Three classes of messages will thus be needed; one arranging the crossings, one advising the trains to be crossed of their crossing points, and the other the simple advice of the running of the train. The crossing stations should be notified first in the following form.

60. **SP.**—Superintendent —— to Agent *C.*

"A special will leave Portsmouth for London at 9.30 A.M., and should arrive at *C* at 10.0 A.M. Keep 8.0 A.M. down train from London till the 9.30 A.M. up special arrives, and cross them at *C.*"

61. And to this the agent at *C* should reply—

SP.—Agent *C,* to Superintendent ——.

"I will keep the 8.0 A.M. down train from London at *C* till the 9.30 A.M. up special from Portsmouth arrives, and cross them at *C.*"

62. Superintendent —— to Agent *B.*

"Advise driver and guards of 8.0 A.M. down train from London that a special leaves Portsmouth at 9.30 A.M. for London, and that the 8.0 A.M. down train must cross it at *C.*"

63. To this *B* will reply—

SP.—Agent *B*, to Superintendent ——.

"I will advise the driver and guards of the 8.0 A.M. down train from London that a special leaves Portsmouth at 9.30 A.M. for London, and that the 8.0 A.M. down train must cross it at C."

64. There now remains the ordinary advice, which would assume the following shape—

SP.—Superintendent —— to Agent *A*.

"A special leaves Portsmouth at 9.30 A.M. for London, and should pass *A* at —— A.M.

65. *A* will repeat this in order to insure correctness, and all other stations should be advised in a similar manner.

66. When this has been done, **and not until then,** the order should be sent to Portsmouth to start the train. The time at which it should start, at which it should pass certain stations, and at which it should cross or pass other trains should be clearly stated, and the whole repeated back to insure correctness. A copy of the message, written in ink, and signed by the agent, should be given to the driver and to the guard, and it should be read to them in each other's presence by the officer in charge of the station.

It will be obvious that the examples given are merely *examples*, and have no connection with the actual working of any section of line. It is improbable any company would make use of a single line route, for a special of such a character as that instanced, when an alternative double line route is open to it.

67. It is equally obvious that at any and all such times as the services of the telegraph cannot be obtained, no such arrangements as those indicated can be made, and

hence no such special should be run. To run such a train, whether during the night or day, without such advice, in writing if possible, if not, then by telegraph, would be hazardous in the extreme.

68. The following points, in connection with the signalling of crossing orders, or special working on single lines, should be carefully observed.

69. The telegraph should in all cases be regarded merely *as an auxiliary and never as a primary agent.*

70. It is the duty of the clerk to receive and transmit the messages. *It is the duty of the agent to carry out the instructions contained in them.*

71. All messages should be *written and signed by the officer in whose name they are sent prior to their transmission by telegraph.* All received messages addressed to him should obtain his signature with the time at which they reach him.

72. Every exertion should be made to keep the wires free, and to secure prompt attention in moments of emergency. *It is when difficulties occur that the patience, skill, and value of an officer is shown*, and this should be borne in mind by every telegraphist. Should trains be delayed beyond their usual time, the wires should not be occupied by useless questions as to their whereabouts. The officer intrusted with the working of the line is the proper authority to make inquiries, and if those interested will watch the instrument all the information sent him will be at their service. Above all is it necessary to avoid quarrelling, obstinacy, and irritable conduct of every description on the instrument.

73. For the reason that should one wire be interrupted, there remains the other to use as a single needle, double needle circuits are preferable for single line working.

CHAPTER IV.

SUPERVISION AND CIRCUIT ARRANGEMENT.

74. It will be readily understood that a system to be effectual must be under *good, careful, and constant supervision.* The staff employed upon single lines should be in every way competent for the duties required; acquainted with the system of working; good telegraphists, possessing, where the double needle is in use, a thorough knowledge of the single needle; and, if possible, having some knowledge of the traffic. All inattention and misconduct should be sharply suppressed, and care taken to see that, not only the clerks, but that the station-masters themselves, perform their allotted duties. All messages should be collected once a week, and checked for errors, irregularities, &c. All crossing orders and *SPs* should be very carefully examined, in order to see that the rules, under which the system is worked, have due effect, and no hesitation should be felt in bringing under the notice of the traffic manager the least departure therefrom. It must be remembered that great responsibility rests with all concerned in dealing with crossing orders, or with messages of any description having reference to the movement of trains; and that any laxity, involving the slightest departure from rules laid down for the government of this important duty, will, sooner or

later, in all probability, produce fatal results; messages upon this subject cannot therefore receive too much care or be dealt with with too much exactitude by those to whom they are intrusted.

75. It is only by such measures, by a periodical inspection of each station, and a careful observation of the conduct and behaviour of every individual concerned, that exactitude can be hoped for, and it is not too much to say that, this obtained, will amply repay any reasonable cost incurred in effecting it.

ARRANGEMENT OF CIRCUITS.

76. Convenience and despatch in all branches of a telegraph service must depend, in a great measure, upon the *arrangement of the circuits.*

77. The head-quarters of every Railway Company should have, if possible, direct communication with all its principal centres, and with the head-quarters of its divisional officers.

78. The head-quarters of each divisional officer should have direct communication with every junction station, and every important station in his division.

79. Every junction station should have communication with the terminal station of its branches, and as far as possible with all stations upon lines converging upon it.

80. All single lines, whether worked by a single engine, the staff system, or the "block," should be provided with telegraph communication. The single engine may break down; the staff may be forgotten, or the engine carrying it fail; and the "block" may be interrupted.

81. The number of stations or instruments upon a *circuit should* in no case exceed eight. As a rule railway

circuits are much over crowded. It is not unusual to find them fitted with twelve and even fifteen instruments. There is no doubt some convenience in giving each station upon a line or branch free intercommunication, but this can be done only, where the stations are numerous, at the cost of despatch, or duplication of instruments. A judicious arrangement of the circuits of a railway system will be found to add to the convenience and despatch of its business, and to economise its cost.

82. Where demands exist beyond those indicated, the grouping of stations, and the centralization of circuits should be based upon returns obtained from the actual work done. To this end, transmitting offices should be required to keep a record for a given time of all messages dealt with, showing the station from and station for. These returns, when analyzed, will show in which direction the demand lies—whether it is desirable to reorganize the existing circuit arrangements, or to extend any of those already in operation so as to afford direct communication, and thus avoid the delay which invariably accompanies retransmission, and the cost attending it. It will not unfrequently be found that the extension of a circuit will effect, in clerks' services alone, an annual saving which will largely exceed the interest on the outlay required for the extension of the circuit, and thus a net saving in the annual cost, independent of other obvious advantages, will be the result.

DIVISION II.

BLOCK SIGNALLING.

CHAPTER V.

HISTORICAL SKETCH.

83. ELECTRICITY was first applied to the signalling of railway trains on the opening of the Blackwall Railway in 1840. At this date the traffic of this railway was worked by ropes—one for the up and one for the down line. The line was four miles in length, and comprised, in all, eight stations, including the terminals, viz., Minories, Cannon Street Road, Shadwell, Stepney, Limehouse, West India Docks, Poplar, and Blackwall. The rope required for each line measured something over eight miles, four miles being laid out over free rollers placed between the metals, the rest being coiled around a drum at the terminal station, at the opposite end to that in the direction in which the train was to proceed. These drums were worked by stationary engines at the Termini—Minories and Blackwall.

84. Taking now the working of a down-train, we should have some four carriages standing at Minories,

one at Cannon Street Road, one at Shadwell, one at Stepney, and one at Limehouse. For stations below there was no communication to Blackwall, the distance being so short. In a similar manner the up-trains were only made up at stations below Cannon Street Road. The train, as made up at the terminal station however, contained a carriage for certain of the stations at which carriages were not attached for the terminal station. Thus in the down-train under consideration, one of the four carriages would be for Limehouse, another for West India Docks, and the rest for Poplar or Blackwall.

We have now the carriages, as stated, standing ready

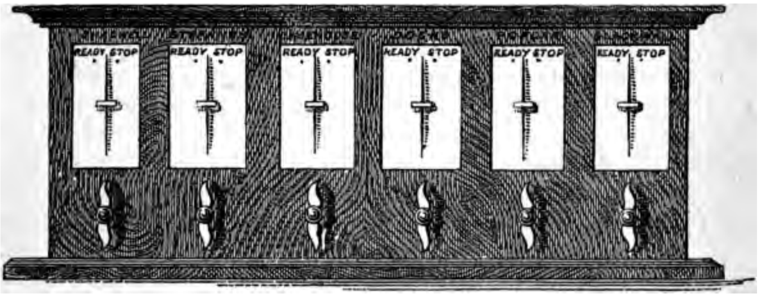


FIG. 13.

for transit to their several destinations. Each carriage is fitted with a means for gripping the rope, and all carriages are provided with conductors and brakes. But before the rope is set in motion it is necessary that the engine-driver, under whose control it is, should know that each carriage *has* its hold of the rope. It was for this purpose that the electrical communication was established.

85. Fig. 13 represents the instrument employed at Minories and Blackwall, Fig. 14, that used at the inter-

mediate stations. Each instrument or indicator was capable of giving, or receiving, two signals—"Ready" and "Stop."

86. The system pursued was this. The carriages were brought up to the stations, the passengers loaded into them, the carriages hooked on to the rope, and the signal "Ready" (made by pointing the needle to the left-hand side) sent. When this signal had been received from each station the engine was set to work and every coach attached to the rope thus put in motion. As each carriage approached its station the guard loosened his hold of the rope and brought it to a stand under the control of the brakes. The up-line was worked in a similar mannei.

FIG. 14.

At times it happened that the rope broke; it was then necessary to stop the engine. This fracture of the rope was easily observed by its want of tension at any station, and immediately such was the case, a signal to "Stop"—the opposite of that indicating "Ready"—was sent either to Minories or Blackwall, according to the direction in which the broken rope was being wound.

Thus, each instrument was limited to two signals—*Ready* and *Stop*. Speaking instruments were also employed, but the duties of the two were distinct.

These were the early days of telegraphy; the speaking instrument had five needles. To work the line there were no less than thirty wires (several being kept spare for repairs). They were of copper, covered with cotton and served with resin for insulation. Fourteen were laid on one side and sixteen on the other side of the

line, in iron pipes, screwed together in the usual manner.

87. In 1842 Mr., now Sir William Fothergill Cook issued a pamphlet called "Telegraphic Railways," which may be said to have established the principles of block signalling. Railways were now making their way, and the necessity of regulating the movements of trains upon some definite principle was becoming apparent. In his pamphlet, which was addressed principally to single-line working, Sir William advocated the division of the line into sections, each of which was to be governed by its own telegraph, and into which no second train should be allowed to enter until the first had been signalled clear of it. The principle here advocated has become the fundamental principle upon which block signalling is based. By it, trains are kept apart by a *certain* and *invariable* interval of *space*, instead of by an *uncertain* and *variable* interval of *time*,—the method originally, and still, to a large extent, pursued.

88. Let A, B, C, D, Fig. 15, be a section of line divided into three parts, AB, BC, CD, and provided with signals at A, B, and C. Now it is clear that if trains are kept apart by the space of any one of these intervals no collision between them can arise. A train enters the section AB. In order to protect it from a following train, the signal at A is required to be kept at *danger* till it arrives within the protection of the next signal, at B. It passes into the section BC; the section AB is now clear, and the signal A may be lowered to admit any following train. On the arrival of the train at B, the signal there has been set at danger, and it has now to be kept in that position till the train arrives at C. But the line signals, which are those governing the engine-driver, can only be worked a limited distance, seldom

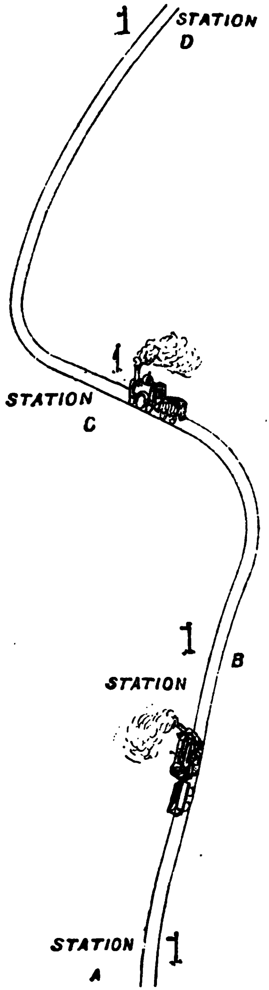


FIG. 15.

sufficient for a block section. It is for the regulation of these out-door (line) signals that electricity is employed. Each signal station is provided with its electrical instrument for up and down trains respectively. The indications of the instrument employed for this purpose must be such as will show whether a train is in the section or not—or in other words, whether the section is *blocked* or *clear*. The out door, or line signals are worked in accordance with these indications, and thus become the exponents of the electrical signals.

89. The principles enunciated by Sir William Fothergill Cook, and thus broadly explained, received their first practical application on the Norwich and Yarmouth section of the Great Eastern Railway, in 1844. Fig. 16. represents the instrument employed. The section of line was divided into five portions. It was a single line, and each station was provided with an instrument similar

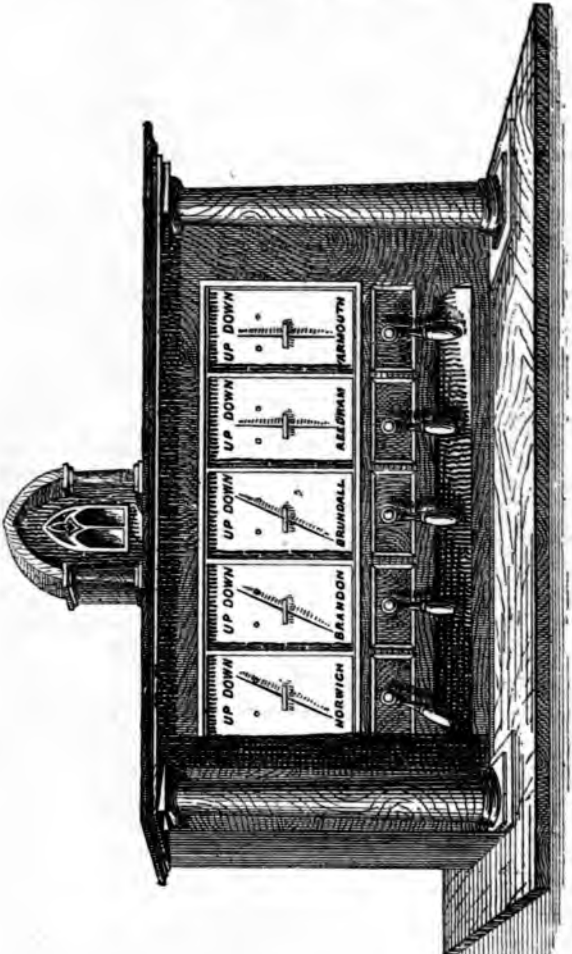

UP DOWN
NORWICH
UP DOWN
BRANDON
UP DOWN
BRUNDALL
UP DOWN
UP DOWN
YARMOUTH

Fig. 16.

to that represented. A train proceeding from Yarmouth to Norwich would be first signalled by Yarmouth to Reedham. The latter would then block over the needle to the up-side, indicating that an up-train was in the section between these two points. Arrived at Reedham, it would be signalled on to Brundall, and the indicator for the Reedham-Brundall section would in a similar manner show its presence between those two points. Clear of the Yarmouth-Reedham section, Reedham would release the indicator for that section, and it would assume the vertical position, showing the section to be free. Thus each station had the power of signalling the progress of the train through the section governed by it, whilst the signal was apparent to all, and in this way every station was cognizant of its progress.

This system, though simple in its mode of working, was cumbersome and costly. Judged by existing systems, it meant multiplying the number of instruments and wires at each signal station by the number of signal stations composing the division ; so that a division of five sections, or five signal-stations, would, worked upon this system, cost something like twenty-five times that of any of the single wire system at present employed.

90. In 1853 or 1854, Mr. Edwin Clark's attention having been directed towards the subject by Captain Huish of the London and North Western Railway, an instrument less costly, more complete, and equally applicable to the subject, was produced, and employed on that line. The instrument employed was the well-known "double needle," Fig. 17. A third wire was provided for a bell or alarum. Thus each signal-station was connected by means of three wires, two being devoted to the double-needle block instrument, and one to the bell. The handles by which the needles were worked were so

arranged that when brought fully over to the right, or to the left, they could be pegged over and so maintained in that position. Each line, up or down, had its own indicating dial, which was arranged to represent three signals, viz., the needle inclined towards the left, "Train on

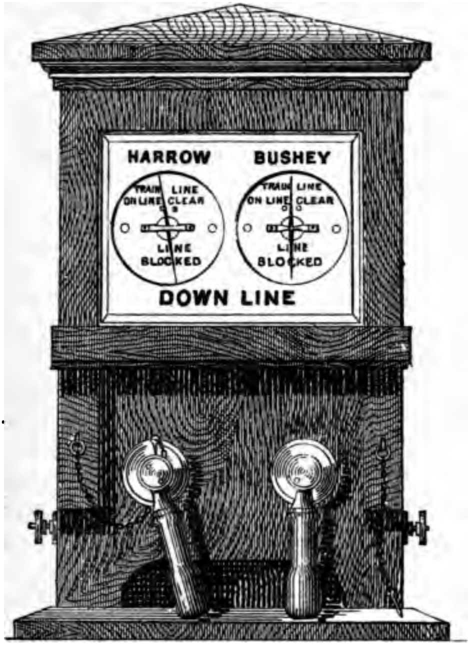


FIG. 17.

line;" towards the right, "Line clear," and vertical, "Line blocked," or "Instrument out of order." The two first-named indications were maintained by constant currents of electricity; the third indication was the normal position

of the needle when uninfluenced by the current. The needles for the respective sections, up and down, thus stood either at "Train on line," or "Line clear," except when the wire became interrupted, either by accident, or by the severance of a small wire forming part of the circuit, which was carried down every alternate pole for the purpose of enabling the guard of any disabled train, by cutting it, to produce the "line blocked" signal.

91. The Great Northern started its block system in 1854, employing the same form of instrument, except that the handles were not arranged for pegging over. Both needles were used promiscuously for the up and down line. The left-hand needle applied to passenger trains: the right-hand to goods and mineral trains. The signals were transitory, being rendered by holding the handle over, momentarily, in the direction of the signal to be indicated, the needle then being allowed to recover its vertical position. All signals were recorded in a book kept for that purpose.

92. Up to 1852 the description of bells employed for block-signalling purposes, or in connection with block-signalling instruments, was electro-mechanical—that is, bells rung by mechanism, the mechanism being put in motion or released by the electric current. Their object was to call attention; and to be ready for use, it was necessary they should be kept wound up and properly adjusted. The former operation had to be performed by the signalman, and was not unfrequently forgotten. The latter called for the attention of the lineman, or inspector, with each material variation of the force of the current, whether caused by leakage on the line wire, or by failing battery power.

93. Hitherto also, block-signalling "had been conducted by means of an instrument, the signals of which

were evident to the eye." In 1852 Mr. C. V. Walker, F.R.S., produced his electro-magnetic or single-stroke bell. It was speedily applied for train-signalling purposes on the South Eastern Railway, and still remains, over a great portion of the line, the means by which the traffic is worked. It is a purely oral instrument, and, as such, its signals are of a transitory character. It will be described further on.

94. During the same year Mr. Tyer produced his first block-signalling instrument. It was provided with two indicators, combined with a treadle worked automatically, so that as each passing train depressed it, its approach was signalled to the station in advance, where the train on its arrival, by similar means, transmitted the "line clear" signal to the station in the rear. The Brighton and the South Eastern lines afforded it a trial, but in 1854 the automatic signalling portion was superseded by hand signalling, keys or plungers being used for this purpose similar in their action to those at present in use.

The apparatus thus modified consisted of an indicating instrument and a bell, or gong, the bell usually being on the down side of the box, that is, to receive signals from the station on the down side, and the gong on the up side of the box, so as to receive signals from the station on the up side. The face of the instrument was divided into two portions, the upper portion being devoted to the up line, the lower to the down line. Each portion had its own indicating needle or pointer, one coloured black, worked by the current from the distant station, and indicating the signal last *received*, the other coloured red, actuated by the outgoing or sending current, indicating the last signal *sent*. The indicators were worked by electro-magnets, the principle of which will be described hereafter. Engraved on the dial were the signals "Train

on line," and "Line clear." Each indicating needle had two movements, one to the right (line clear), the other to the left (train on line).

95. Immediately below the dial were two keys, or plungers, by which the signals were worked, one being appropriated to the block, or "train on line" signal, the other to the "line clear" signal. When pressed in, the line wire was placed in circuit with the battery, and a current thus passed out through the coils, actuating the red indicator, to the distant station, where, after operating the black needle, it passed into the earth. When in its normal position, the line-wire was in connection with the coils of the black indicator. Thus, supposing station A required to signal "Train on line" to station B, the signalman at A called B by pressing one of the plungers a specified number of times. The signalman at B then pressed in his "train on line" plunger, which caused his red indicator to pass over to "Train on line," and the black indicator at A to coincide with it. On the arrival of the train at B, the "line clear" signal was sent by pressing the plunger for that signal which reversed both the red needle at B and the black needle at A, causing them to indicate "Line clear." The black indicator thus became the *block* signal and the red indicator the *recording* signal.

The handling of the plungers or keys required some care on the part of the operator in order to avoid mistake, but improvements effected in the more recent forms of these instruments reduce this danger.

The bell or gong was constructed on the electromagnetic principle, similar to that of Walker's, and was a great improvement upon the electro-mechanical bell hitherto in use, as by it, separate and distinct blows were sounded each time a current was transmitted to the distant station.

96. The introduction of Mr. Tyer's instrument served but to herald the advent of that invented by Mr. Bartholomew. Both made their appearance in or about the same year. The outward form of the instrument is shown in Fig. 18. The face of the instrument, like Tyer's, was divided into two portions, one for the up, the other for the down traffic. Each portion had its own indicator. Each indicator was capable of assuming two positions, one to the left, "Clear," the other to the right, "Closed," which signals were rendered by means of the two knobs,

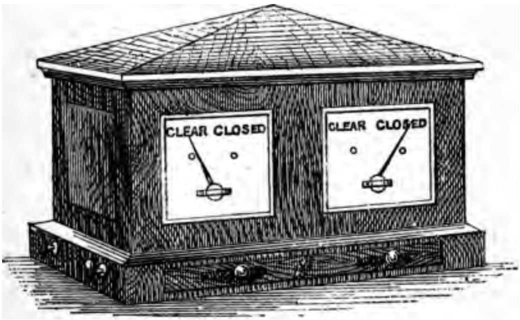


FIG. 18.

seen immediately below the needles. A pressure of either to the right gave the "closed" signal, and a pressure to the left the "clear" signal. The right-hand knob was for the down line, or down traffic, and the left-hand for the up. The outer needles, or pointers, were fixed upon spindles which also carried an inner needle or magnet, free to move between two poles of an electro-magnet. Placed in front of these poles was an armature carrying a small rod with a hammer-head fixed upon it, in such a position that it should, when drawn forward by the attrac-

tion of the armature at each passage of the current through the coils, strike a bell-dome placed within its range and within the instrument case. Thus on A signalling to B, the knob was carried over to the left, and the battery current sent through the instrument coils at A into the line. Arrived at B, it passed through the coils of the indicator there, carried the needle over to the "clear" side, and attracting the armature, caused the hammer to strike the bell. The instrument was compact in form but required two wires for each section for up and down trains. The indicators were maintained in the position last placed by the current, by gravity, being weighted for that purpose. Worked by momentary currents, their position was easily reversed by lightning or contact. The instrument was used for some time on the Brighton and South Coast line, but has of late years been superseded by Tyer's.

97. To Mr. W. H. Preece is due the credit of having done perhaps more to popularise block-signalling than any other engineer. In 1862, the London and South Western Railway completed its connection between the Exeter Queen Street and the St. David's stations, by means of a somewhat unusually severe incline. Block-signals were required for working it. To meet this demand Mr. Preece invented his system, the characteristic of which is, independent of its electrical advantages, its assimilation, in form and mode of working, to the outdoor form of signals in use for the guidance of the engine-driver. In the session 1862-3, he read before the Society of Civil Engineers a paper which drew considerable attention to the subject of block-signalling. Regarding it as a fact that one reason why the adoption of block-signals had been, up to that time, so slow and *partial, was* the difficulty of teaching those to whom they

had to be intrusted, the method of working them, he aimed at placing in the hands of the signalman a form of instrument, so similar to that used by him out-of-doors, as to destroy at once that timidity which something so different in character and management to those in use but too frequently inspired men of this class. Thus, he caused the block signal to assume the form of a semaphore or disc, the arm or disc of which was actuated by the electric current in a manner corresponding to the movement of the outdoor signal. In like manner, the instrument by which this signal was worked, was constructed after the fashion of the lever by which the distant signal itself was wrought—a miniature lever, as the block signal was a miniature semaphore. The electric signals thus became in form and in manipulation a repetition of the line signals, with the working of which every pointsman and every signalman was conversant. No greater proof of the aptitude of the idea thus conceived and carried out need be produced than the fact that it was speedily taken up by Messrs. Tyer and Walker, the former employing the semaphore arm in the place of his needle indicator, and the latter as an adjunct to his bell system.

Independent, however, of the advantage thus gained, another most important step was secured by Mr. Preece. The bell employed by him was constructed, not only to indicate by the number of beats signalled, the nature of the signal sent, but also to record *the condition of the block signal at the distant station.* In all other forms of instruments where this is shown, we see it done by the out-going current. Thus it is in Tyer's, in Walker's, in Spagnoletti's, and in the double or single needle systems. With Preece's this is effected, not only by the distant station, the *station to* which the block or clear signal

has been sent, but it is so effected that the current used for the bell signal depends upon the actual position which the block signal has been caused to assume. Thus when *A* puts up the arm of the electrical semaphore at *B*, the semaphore places in circuit with the bell-key that battery current—copper or zinc—which shall cause a movable indicator on the face of the bell fixed at the station from which the semaphore is wrought to read "Signal ON at B," *so that the signalman not only knows he has, by his own action, sent the block signal to B, but that it has been received at B, and that the semaphore arm there actually stands at danger.*

The principles which characterised this form of instrument at its introduction still attach to those now in use, of which a more detailed description will be given hereafter.

98. At or about the same period which saw the introduction of Preece's system, came also into notice a modification or adaptation of the single needle, as a block instrument, by Mr. Spagnoletti, of the Great Western Railway. It was adopted by the Metropolitan Railway, and is still in use on that and the Great Western lines. Being one of the forms of instruments at present in use, it will be described more fully under that heading.

99. In 1866, Mr. Preece introduced his single wire system. Though considerably improved in 1872, it may also be considered one of the systems of the present day and will be fully described as we proceed. It retains all the outward characteristics of his earlier three wire system, but like all single wire systems its signals are produced by momentary currents of electricity; the evil of which is, that permanent or polarized magnets being employed, foreign currents, either atmospheric, or by the

signal wire coming into contact with other wires, may, unless specially provided against, be conveyed to the block signal instrument, and so produce a reversal of the signal without the knowledge of the station which governs that signal, and at a moment most inopportune for the safety of the traffic. To meet this Mr. Preece so arranges his instrument that the *all clear* signal *can only be produced by the concurrent action of the signalmen at both ends of the section.*

From this date to the present time there has been little change in the main characteristics of block signalling instruments. Improvements have from time to time been effected in every form, the double and single needle, perhaps least of all; still, without doubt, all alike are superior in character and manufacture to the earlier instrument of the same type. Many of the earlier forms are still retained by those companies which first adopted them. The Great Northern, the North Western, and others, having adopted the earlier kind of instrument, and extended it throughout a great portion of those systems, would find some inconvenience in introducing a system totally distinct in its mode of working. But whilst some allowance must be made for established systems, it yet remains a grave question if this inconvenience is of such weight as to preclude the use of other instruments possessing well-known advantages.

CHAPTER VI.

INSTRUMENTS AT PRESENT IN USE.

ELEMENTARY PRINCIPLES.

WITH the exception of the needle form of instrument already described (§ 13), all the block-signal instruments of the present day are worked by *electro-magnetism.*

100. An **electro-magnet** is formed by winding a quantity of insulated wire around a piece of iron. Let

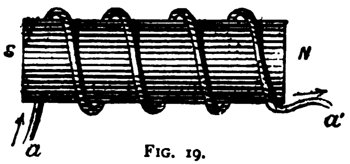


FIG. 19.

N S, Fig. 19, represent such a piece of iron, and *a a'* an insulated wire wound around it. If a current of electricity be passed through this wire, its influence upon N S will be such as to impart to it magnetic powers, and it will assume a polarity *subject to the direction of the current.* If the current be in the direction indicated by the arrows, the polarity will be as shown by the letters S (south), N (north). If the direction of the current be

reversed, the polarity will also be reversed ; S will become north, and N south.

101. The piece of iron N S is called a **core.** If it be of the best annealed soft iron, the magnetism acquired by the passage of the current will, practically for the purpose in view, cease to exist with the cessation of the electric current. If, on the other hand, the iron be of inferior manufacture, it will retain its magnetism, but in a reduced degree, for a period governed by the purity or

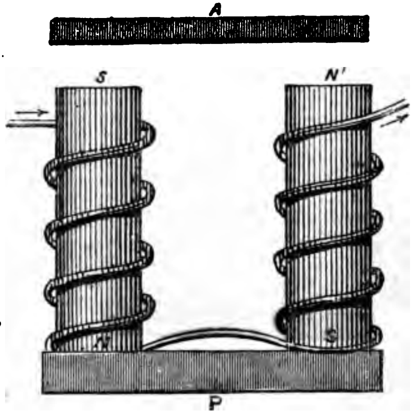


FIG. 20.

impurity of the metal. The best and softest iron should as a rule be used, as, ordinarily, an electro-magnet is only required to be active during the passage of the current through the coils of wire by which it is surrounded.

102. Two cores N S, N′ S′, coupled by a soft iron plate P, and wound with insulated wire in the manner represented in Fig. 20, form a more powerful electro-magnet than that described, and it is the form generally employed.

If, during the passage of the current through the coil wire, the iron bar A be brought within the immediate neighbourhood—termed the **magnetic field**—of the cores S N′, it will be attracted towards them and forcibly retained in that position until the current ceases to flow through the coils, when it may be readily withdrawn.

103. If A, Fig. 21, be hinged at one extremity *b*, and its other extremity *c*, be placed under the control of a spiral spring *x*, the tendency of which shall be to withdraw it (A) from the neighbourhood of S; during the passage of every current A will be attracted towards S, so

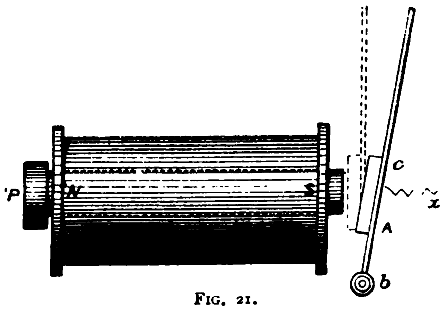


FIG. 21.

as to assume the position indicated by the dotted lines; but on the cessation of the current, S being no longer magnetic, the influence of the spring *x* will predominate, and A will be withdrawn from the dotted to the normal position.

A being simply a piece of soft iron, and in no way of itself possessing magnetic powers, will be attracted by the electro-magnet N S on the passage of *every current* of electricity *whatever its direction.*

The bar A is termed an **armature**. Hence we have *the means of* producing a backward and forward **move-**

ment, with the passage of every electric current through the coils of the electro-magnet. This movement may be employed to ring a bell, move a semaphore arm, or do other work of a like character.

104. If now, Fig. 22, we take a small permanent magnet *n s*, pivoted at A, and place it in the neighbourhood of the electro-magnet, so that it may be free to move between the poles S N, as shown in the figure, we shall find, on passing a current through the coils, that it will be attracted by the one pole and repelled by the other. If the coils be wound as indicated in Fig. 20, and the current passing through them be in the direction

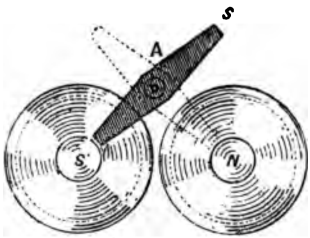


FIG. 22.

indicated by the arrows, the position of the magnet will be that shown in the figure. If the current be passed through the coils in the opposite direction, the magnetism of the cores and the position of the permanent magnet will be reversed; S will become N, N will become S, and the position of *n s* will be that indicated by the dotted lines. Hence, then, we obtain a means of producing **motion, governed by the direction of the current.**

In the former case (§ 103) we have **motion, independent of the direction of the current,**

but here we have **motion, subject to the direction of the current.**

Upon these principles are mainly based the action of all modern electrical block signals.

105. The different forms or systems of recognised block-signalling instruments, at present in use in Great Britain are six, viz :—

Cook and Wheatstone's needle instrument.
Preece's three-wire semaphore system.
Walker's semaphore.
Tyer's semaphore.
Spagnoletti's disc.
Preece's single wire semaphore system.

106. The first of these—**Cook and Wheatstone's**—has already been described. It is the ordinary double needle instrument (§ 18) used by the Electric and International Telegraph Company in its early days for commercial purposes, and still used on many railway systems for message work. It has, however, shared with the single needle, the improvement effected in it at the time of the transfer of the telegraphs to the State. One of its defects was the liability of the small needle magnet inside the coils to be partially, sometimes entirely, demagnetised, or even to have its polarity reversed, by lightning. In this manner the movement of the needle entirely failed, or the signals were reversed—in the latter case "Line clear" being represented by "Line blocked," and "Line blocked" by "Line clear."

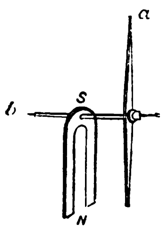


FIG. 23.

107. To remedy this a soft iron needle *n s*, of the shape shown in Fig. 23 is fixed

to the spindle *b* carrying the indicating or outer needle *a*, in the place of the small permanent magnet formerly used.

To the upper portion of the inner coil cheeks are fixed two permanent bar magnets NS, N′S′, Fig. 24, so that their similar poles shall be adjacent to each other. *n s*, being within the magnetic field of these permanent magnets, acquires from them magnetic properties, with a polarity as indicated by figure 23, and performs precisely the same functions as the permanent magnet which it replaces. The two-bar magnets NS, N′S′, will in course of time require remagnetizing. It is possible, although unusual, for them to become demagnetized by lightning, but no case is recorded of their polarity having been changed under atmospheric influences.

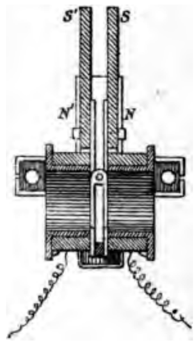


FIG. 24.

108. Fig. 17 represents the complete instrument It may be used for block-signalling purposes in the manner previously described (§§ 90, 91). It is better for the *block* and *clear* indications to be rendered by permanent than by momentary currents. With a permanent signal there is always an object of reference, but with a momentary, or transient signal, there is nothing beyond the book record; and although every signal ought to be recorded as rendered, it is not, and cannot be, where the signalling has to be carried on, and the records made, by one and the same person, always done. With a momentary current system "Line clear," may be rendered by

atmospheric electricity or contact. With a permanent signal, produced by a permanent current, this can only be effected when the magnetism of the needle becomes reversed by atmospheric electricity.

The instrument is available for speaking purposes, and

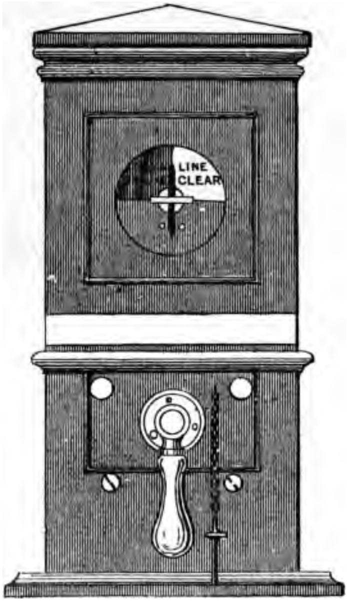


FIG. 25.

on this account is objectionable as a block-signalling instrument. Men are prone to relieve the monotony of a perhaps tedious duty by a passing remark with their neighbouring station. Conversation of this character leads to forgetfulness, and an error is easily made at such

moments. It is not desirable to place in the hands of men means, which even under remote circumstances, may admit of error.

109. Where one needle only is required a single needle instrument, such as is represented in Fig. 25, is employed.

CHAPTER VII.

PREECE'S THREE-WIRE SYSTEM.

110. MR. PREECE's three-wire system is a permanent current system only as regards the rendering of the *clear* signal. The *block* or *danger* signal is produced by gravity. The apparatus employed consists of four parts, viz., the *semaphore*, the *switch*, the *bell*, and the *bell-key*.

111. Fig. 26 is a transverse section of the **semaphore** instrument showing its internal arrangement. E is an electro-magnet, C a rocking lever, centred at B, at which point it is rigidly connected with the armature A. At *d* it is connected with the arm by means of a small wire-rod *e*, which is eccentrically attached to the arm H at *f*. G is a small movable weight, the object of which is to so influence the lever arrangement, that in its normal condition, the armature A shall be carried away from the electro-magnet E, and the arm H, raised to *danger*.

If now a current be passed through the coils E, A will be attracted, the lever C will be raised at its extremity *d*, the rod *e* will receive an upward movement and the arm H, will be depressed to the all clear position. On the cessation of the current, the coils will lose their attractive power, the armature A will be released, and the

weight G, now coming into operation, will again raise the arm to danger.

The extent of the movement of the lever C, is con-

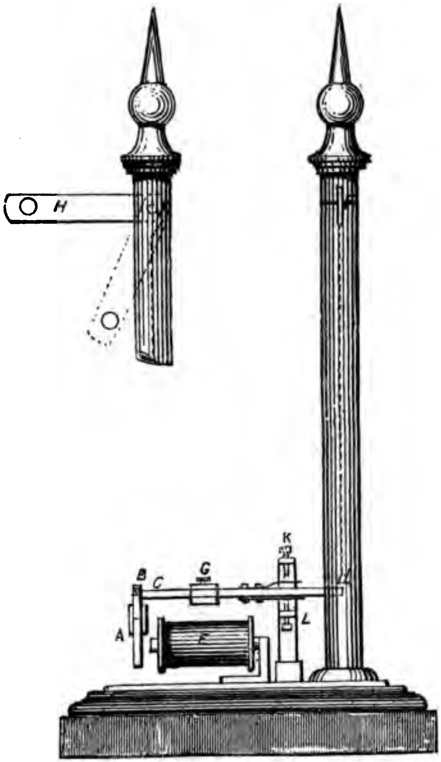


Fig. 26.

trolled by two cocks, provided with necessary adjusting screws, *L which* regulates its downward action, and K,

which controls its upward motion. It is necessary that the influence of the weight should be sufficiently pronounced to insure the small spring attached to C for that purpose, making good contact with L; and that the adjustment of K should be such as to secure an equally good contact when the lever C is raised at *d*, by the attraction of A towards E.

The two cocks K, L, serve, not only as a means of adjustment for the lever C, but are requisite for the purpose of repeating back to the signalling station the position

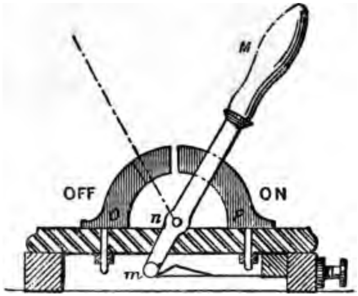


FIG. 27.

of the arm. It will not, however, be necessary to refer to them further for the present.

112. Fig. 27 is a transverse sectional representation of the **switch,** and Fig. 28 is an outside front view of the same. The lever or handle M, centred at *n*, is free to move backwards and forwards within the slotted segments O, P. At its extremity *m*, it is fitted with a small steel roller, which on the movement of the lever from one side to the other, traverses a spring provided with a *double* inclined plane, the object of which is to exercise such influence over the lever M, as to admit of its move-

ment from the position in which it has been last placed,

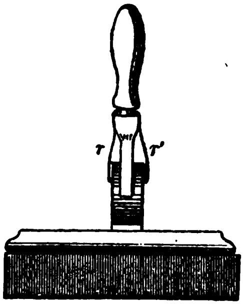


FIG. 28.

only under the exercise of some slight force. The lever M is provided with two springs, *r*, *r'*, Fig. 28, one on

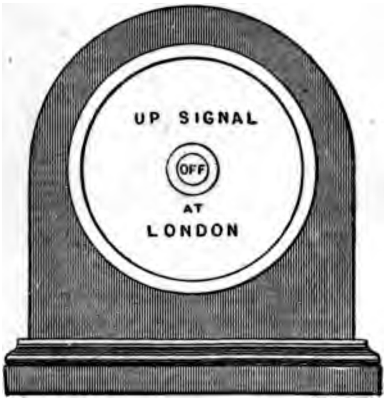


FIG. 29.

either side, so arranged that they shall press against the segments O, P, according to the position of M, and so

secure good contact between it and the segment. The segment O is lettered OFF, and that marked P, ON. The instrument is provided with three terminals, one of which is in connection with M, another with O, and the third with P.

113. The **bell** is shown in exterior in Fig. 29; inside section in Fig. 30; and in end section in Fig. 31. Q Q′ is the electro-magnet. R, the armature centred at *r*, carrying the bell-hammer rod *r′* with the hammer at its

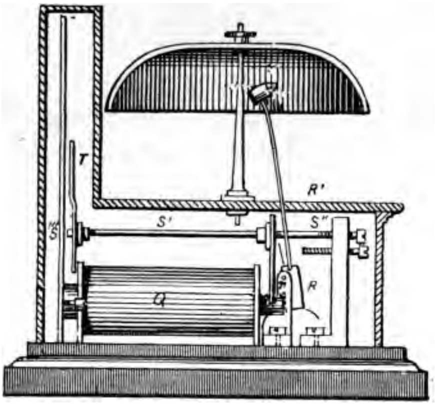


FIG. 30.

extremity. S is a small magnet fixed upon a spindle *s′*, pivoted at *s″* and *s‴*. Affixed to this spindle at the opposite end to S is a shield T, carrying the words [ON, OFF]. The movement of the magnet S is so arranged that one of the sentences, "ON" or "OFF," shall be shown at the aperture in the face of the instrument (Fig. 29), in whichever position S may be placed. *To R is attached a* small locking pin *u*, which when the

armature is at rest passes on one side of the magnet S, as indicated in Fig. 31, and so locks it in that position. To R is also affixed a steel spring, not seen in the figures, which, on the armature being attracted by Q, presses against the adjusting screw seen immediately below s″, the object of which is to restore the armature to its normal position on the cessation of every current passed through the coils.

If now a negative current be sent through the coils Q, R will first be attracted and the bell dome struck; the

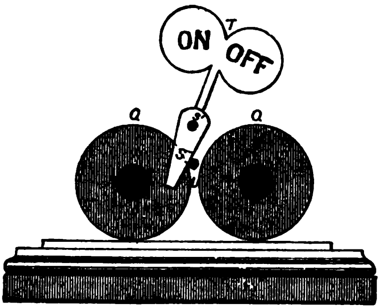


FIG. 31.

locking pin *u* having freed S, it will assume the position shown in Fig. 31, exhibiting the word ON at the aperture in the face of the bell, which will thus read, "Up signal ON at London." On the cessation of the current, R will be restored to its normal position and the small magnet S, locked to the ON signal. If we repeat this current there will be no change in the *indication* of the bell, but another stroke will be struck on the bell dome.

But if now we send a positive current through Q, the attraction of the armature R, will be the same, and the

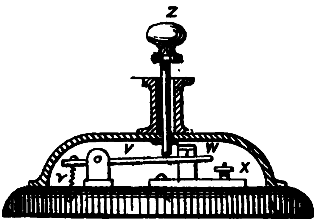


FIG. 32.

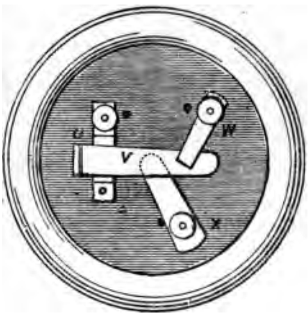


FIG. 33.

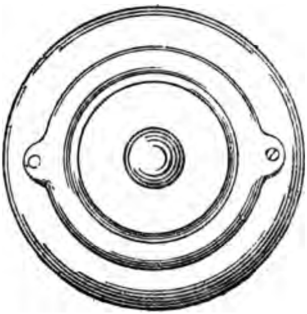


FIG. 34.

bell dome will be sounded as with the copper current, but S will, in this instance, on being released by the locking pin *u*, pass over to the core of Q′, and now the word OFF will take the place of the word ON at the aperture in the face of the bell, and the indication will read, "up signal OFF at London."

Thus (§ 103) for each current received from the distant station, whatever its character, whether positive or negative, the bell is sounded; whilst (§ 104) the indicator, ON and OFF, is, on the contrary, influenced by the direction of the current, that recognized as the positive current exhibiting the word OFF, and that as the negative, the word ON.

114. The **bell key,** or **"Plunger,"** is the instrument by which the bell is worked. It is shown in section in Fig. 32, in plan in Fig. 33,

and with its case on in Fig. 34. V, is a small lever capable of being moved from the stop-piece W, in forcible contact with which it is kept by means of the spring *v*, to the lower contact X. The lever V, is in connection with the bell-line wire; the lower contact X, with the semaphore; and the upper contact W, with the bell. The plunger knob, Z, is fixed upon a rod surrounded by a spiral spring within a small tube, the object of the spring being to raise the rod free of the lever V when not in use. On pressing Z the lever V is carried away from W, and brought into contact with X.

115. Fig. 35 shows the **electrical connections** between the several portions of the apparatus for one end of a section for both up and down trains. One wire is devoted to the up-line, another to the down-line, and the third to the bell, which is thus common to both.

Fig. 35A is an outward representation of two complete sets of these signals, showing their arrangement for an intermediate signal box. The shelf or frame supporting the switches, bell-keys, and semaphores, stands just above, and free from, the levers by which the out-door signals are operated.

116. The following is the **method of signalling** usually adopted. A train is about to start from **A** to **B**. A warning signal is first sent to **B** to say "train coming." This is done by signalling twice two beats on the bell. The train then—provided the semaphore arm indicates that the road is clear—leaves, and its departure is signalled by **A** to **B** by two beats on **B**'s bell. **B** acknowledges this by raising the semaphore arm at **A**, and so blocking the road against any following train. **A** acknowledges this by one pressure of his bell-key which sounds **B**'s bell once, and causes the indicator on its face to read, "Down signal ON at **A**." On the

arrival of the train at **B**, the semaphore arm at **A** is lowered and his bell sounded three times by **B**. **A** acknowledges this by one stroke on **B**'s bell, which also causes the indication on its face to read—

DOWN SIGNAL
OFF
at
STATION **A**,

which terminates the transaction, and restores the instruments to their normal position.

117. We will now, by the aid of Fig. 35, trace certain of these transactions in order to observe the working of the several portions.

It may be assumed that the warning signal has been sent and acknowledged. The departure signal is now given. **A** presses the knob of his bell-key twice. The lever V is brought into contact with X, X is in connection with the weighted lever C of the semaphore, which is in contact with the cock K, and this cock is in connection with the copper pole of a battery, the other pole of which is to earth. Thus we have, on pressing V, a copper or positive current flowing from the battery to K, from K to C, and by the wire connecting it with the bell-key, to X, with which V is, by the pressure of the bell-key knob, in contact. From V the current passes into the bell line wire, and so on to station **B**, where it enters by the bell-key at V, which in this case would rest, as is shown in the diagram, against the stop piece W, and which is in connection with the bell coils, through which it passes, operating the bell as explained in § 113.

Corresponding with the number of currents sent, which depends upon the number of times the bell-key is pressed, will the bell be sounded. The position of the

indicator on the face of the bell however, depends upon the *nature* of the current. In the present case a positive

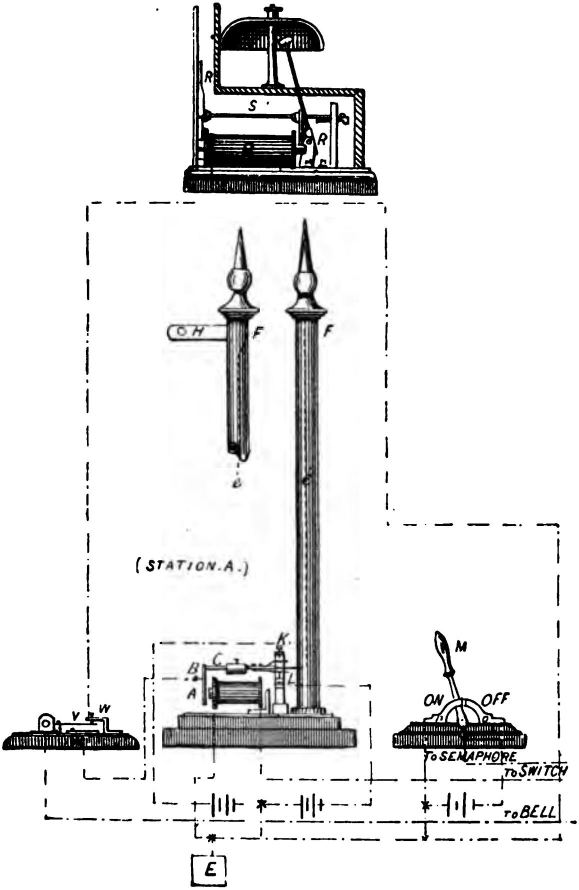


FIG. 35.

current has been sent, and the indicator will read, "Signal OFF at **A**," the semaphore arm there being at *all clear*.

B now understands the train has left **A**, and in order to prevent another following it till it arrives at **B**, he passes his lever handle over to ON. M is now in contact with P, and P is connected with the "earth." No current passes out by the switch; the electro-magnet E of the semaphore at station **A** is no longer excited and the weight *g* carries A away from E, and raises the arm to the *danger* position as shown in the figure.

Station **A** acknowledges this by pressing V once. But **A** no longer sends to **B** a current of the same character as that previously transmitted. The position of the semaphore arm has been changed by the movement of the lever C, which previously rested upon K, and which now rests upon L, L is in circuit with the zinc pole of the battery, and thus a negative current is brought up to X, and on the pressure of V passes into the bell wire and so on to **B**. Arrived at **B**, it passes through V and W to Q, which it excites and again rings **B**'s bell. The current is of a reverse character to that formerly sent, and the magnet S, Fig. 31, is consequently carried over towards Q, and the indication on the face of the bell now reads—

DOWN SIGNAL
ON
at
STATION **A**.

On the arrival of the train at **B**, he draws his lever, M, over to OFF. M now comes into contact with O, to which is connected the switch battery wire. A current then traverses the down semaphore line wire to *station* **A**, and passing through the semaphore coil, E,

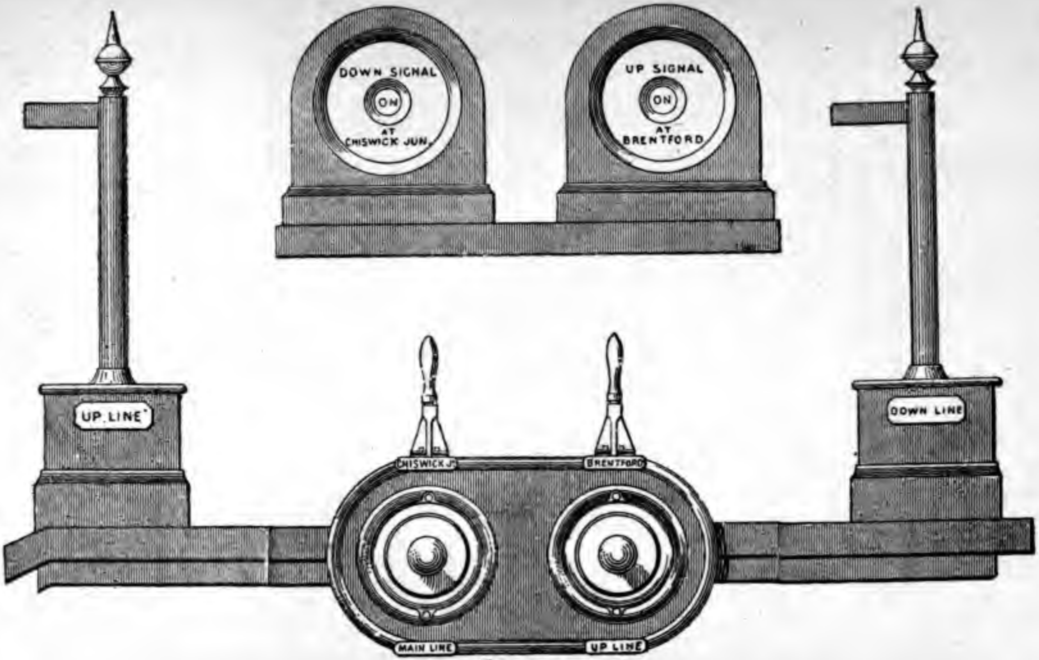

DOWN SIGNAL
ON
AT
CHISWICK JUN.
UP SIGNAL
ON
AT
BRENTFORD
UP. LINE
DOWN LINE
CHISWICK J^{n}
BRENTFORD
MAIN LINE
UP LINE

FIG. 35A.

attracts the armature A, centered at B, which raises the rod *e*, and so depresses the arm, indicating the line is *clear* to **B.**

A acknowledges this by pressing his bell-key (V) once, and the position of G having again changed from contact with L, to contact with K, a copper current is transmitted to **B,** which in sounding the bell there also reverses its indicator, causing it to read—

DOWN SIGNAL
OFF
at
STATION **A.**

The "clear" signal is thus obtained by a constant current from the distant station. Neither station has any control whatever of its *blocked* or *clear* signal, *both are wrought from the distant station, that to which the train is proceeding.* The repetition or record of the condition of the block signal (the semaphore arm), whether ON or OFF, *is obtained automatically from the semaphore signal itself, and is beyond the control of both the signalman who renders it and the signalman by whom it is received.*. The interruption of either semaphore wire at once places the signal at danger. Atmospheric electricity has no effect, the connection between M and P opening up a road for it direct to "earth."

CHAPTER VIII.

WALKER'S SEMAPHORE SYSTEM

118. FIG. 36 is an outside representation of the **semaphore instrument**, and Fig. 37 of that of the **keys** or **plungers** by which it is worked.

The arm to the left of the signal post is the "*block*" arm, and is coloured *red*. It is worked from, and is under the control of, the signalman at the *distant* station.

The arm to the right is coloured *white*, and is intended to represent the position of the "block" arm at the adjoining station. It is worked by the *outgoing current* of the station from which the block or clear signal is sent.

The *signalling keys* are usually fixed in the position represented in the figure, the upper key on being pressed inwards sending the block signal, and the lower key the clear signal.

Fig. 38 is a side, and Fig. 39, a rear-elevation representing the **internal arrangement** for working the red arm and ringing the bell. That for working the white arm is placed above this, and, except that its electrical arrangement is reversed, and that it is smaller, is in every way similar: there is, therefore, no necessity to represent it here, but it will be found in outline in the figure showing the electrical connection.

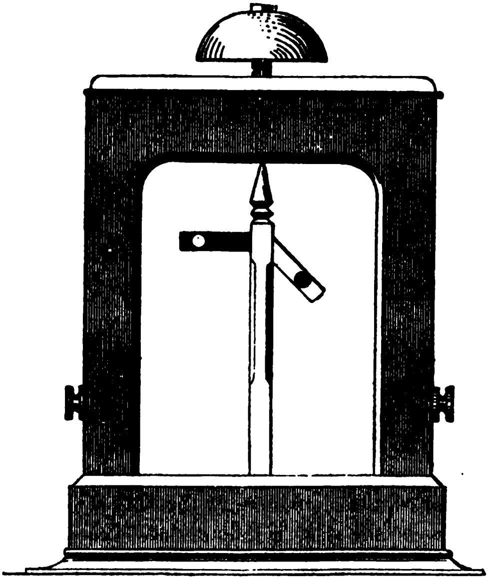


FIG. 36.

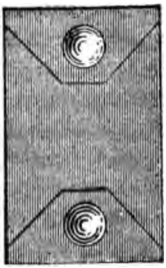


FIG. 37.

119. A A is an electro-magnet, of which C C are its cores. M an armature carrying the bell-hammer T; S is a spring the object of which is to carry M away from the cores C C′ on the cessation of the current. *m m′* are two bent steel permanent magnets, joined together by a piece of brass B, pivoted at its centre, and so fixed that their poles shall be within the magnetic field, and on either side of

the cores C C′. These cores are reduced in size outside the coils, from which they project some distance, and pass through the armature M, being covered at their extremities by wooden or ebonite guards G G′. R is a small rigid rod fixed at right angles to B. The

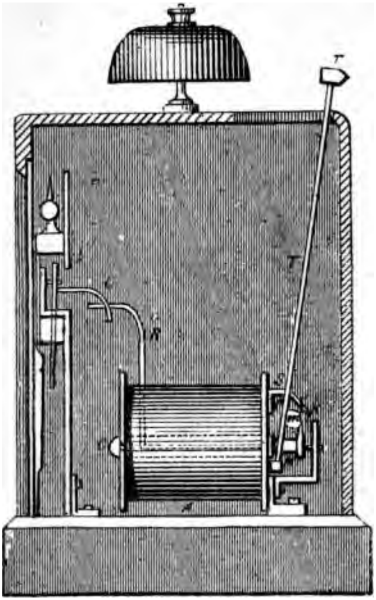


FIG. 38.

semaphore arm is so arranged that it shall, by its own weight, fall to the *clear* position. Affixed to it is a small wire bar L, bent to the shape shown in the figure. The tendency of the arm to fall to *clear* keeps this wire bar resting against R. To the rod T is fixed a small pin, K,

which prevents the movement of *m*, except when the armature is attracted to C, and so controls that of R, and consequently that of the arm.

120. If now we follow the action of a current passed through the coils, we shall have a clearer view of the objects, and of the action, of the several parts. Let it be assumed that the arm is in the position shown in Fig. 39,

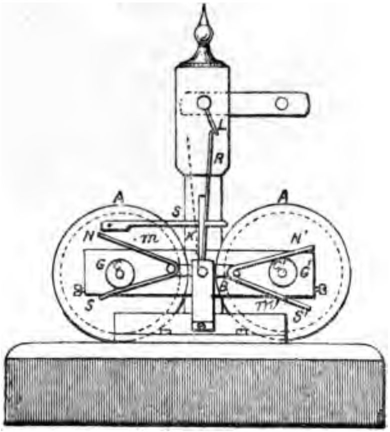


FIG. 39.

and that it is desired to lower it to the "all clear" position. On the current passing through the coils A A, the cores C C′ become magnetised, M is attracted, and the bell sounded. Whilst M is thus attracted, the locking pin K is removed from the neighbourhood of *m*, and the bent magnets *m m′* are free to move. C has acquired a south polarity, and C′ a north polarity; the N arm of *m*, and the S arm of *m′* are consequently attracted, as the opposite arms of the same are repelled by C and C′ respectively.

The rod R, moving with the brace-piece B, is carried over to the dotted position, and being followed by the projecting pin L, the arm falls to the all clear position. On the cessation of the current the armature falls back under the influence of the spring S, and the pin K, again locks *m*, at the all clear position.

An opposite current would attract the armature, causing the bell to be sounded, in precisely the same manner, but having induced an opposite polarity in the cores C C′, the position of the permanent magnets, *m m′*, would again be reversed, and the rod R, carrying with it the projecting pin *l*, would raise the arm to the danger position.

121. The **internal arrangement of the keys** is shown in perspective in Fig. 40. *b* is a flat spring, insulated at either end, fixed at its centre so that either extremity may be pressed down by its respective key or plunger. *d* is another spring pivoted at one end, and insulated at its other end, but operated by the lower plunger only. Each spring makes and breaks contact with the cocks *c* and *e* respectively. The plungers, retained in their position of rest by spiral springs, make contact on pressure at *l* and *g*.

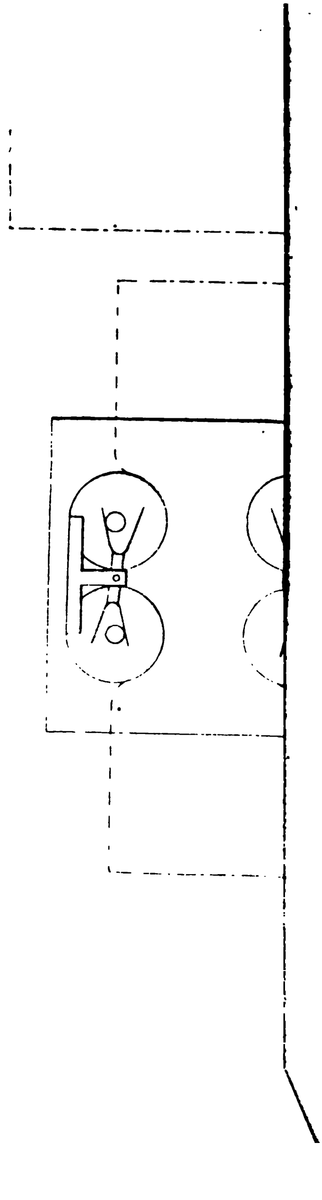
122. Now, assuming that the signalman at **A** wishes to block station **B** he raises the red arm at **B**, and to do this he has to press the upper plunger. In doing so he carries the spring *b* away from its position of rest in contact with the cock *c*, disconnecting *e* and *d* from *b*—that is, disconnects his red arm coils from the line wire, and so throws them out of circuit for the time being. The disc *f*, at the same time, is brought into contact with the plate *g*, a positive current flows to *c*, through the plunger rod to *g*, and thence by the white arm coils, raising the white arm, and away to "earth"; the zinc pole of the

battery completing its circuit by way of the rod of the lower plunger, connection *i* of the spring *b*, plate *a*, and on to station **B**, where it enters at *a*, passes to spring *b*, contact *c*, spring *d*, contact *e*, thence to the coils, raising the red arm, and to " earth."

When **A** requires to lower his own white, and **B**'s red arm, he presses his *lower* plunger, which throws his red arm coils out of circuit by breaking the contact, between spring *d* and the cock *e;* and at the same time, by way of the disc *k*, connects the negative pole of the battery with *l*, passing the zinc current through the upper coils of his instrument (lowering his white arm) to earth; whilst the opposite pole of the battery forms its circuit by way of the plate *c*, contact *e*, spring *b*, terminal *a*, and passing along the line wire enters **B**'s lower coils (lowering his red arm) and passes to earth.

The plunger springs *b* and *d* are saved from overstraining by the collar of the plunger knobs banking against the brass plates c and z.

The semaphore instrument is simple and the working parts are massive and strong. If the small magnets *m m'* were influenced by induced, instead of permanent magnetism, there would probably be less liability to the reversal of signals from atmospheric electricity, although from the fact that a large gauge wire is employed for the coils, the possibility of this is in a measure reduced.



CHAPTER IX.

TYER'S BLOCK SIGNALS.

123. FIG. 41 is a sketch of a complete set of instruments for working both the up and down traffic, as fixed at one end of a section. It consists of—

I. A bell or gong, embracing a relay.
II. An indicating instrument, embracing—*a*. Two indices (or arms), the one to register the incoming, the other the outgoing, signals—*b*. a pair of plunger keys, the one for the *block*, the other for the *clear* signal.
III. A ringing key for bell or gong signals only.

The set of instruments for working the other end of the section would be identical, except that it would be provided with a bell in the place of the gong.

The lower index is coloured red, and is in circuit with the upper or black index, at the next signal box. The red index indicates the last signal sent; the black the last signal received. On the movement of either, the gong or the bell, as the case may be, should be sounded, so that any change made on the outgoing signal ought not to occur without the signalman at the next station being warned.

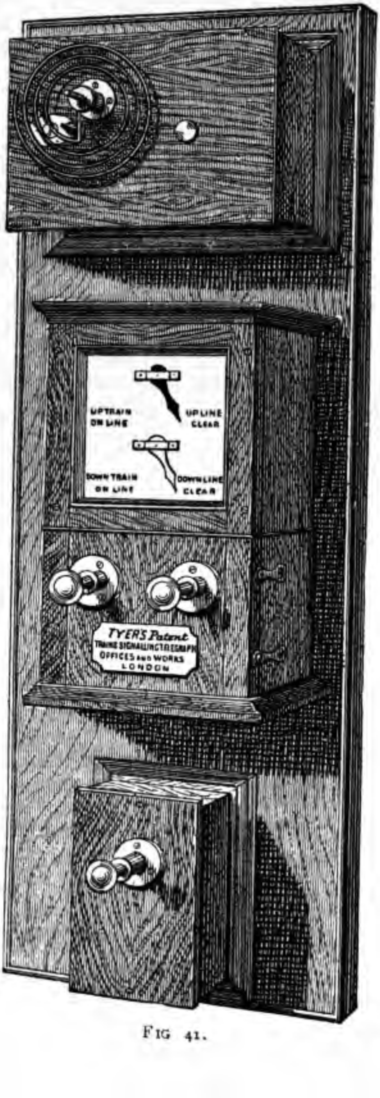

UP TRAIN
ON LINE
UP LINE
CLEAR
DOWN TRAIN
ON LINE
DOWN LINE
CLEAR
TYER'S Patent
OFFICES AND WORKS
LONDON

FIG 41.

The plungers are so arranged that, although they send reverse currents, and consequently change the position of the indices to correspond, they leave the commutator fixed, so that any number of strokes may be subsequently sounded by the bell or gong plunger without altering the position of the indicator.

The bell is rung by means of a relay, which being merely an electro-magnet with soft iron armature, is actuated by every current irrespective of its direction or character.

The magnetic circuit of the registering index for the outgoing signals is placed between the battery and the earth, whilst that belonging to the index for the incoming signals is disconnected from the battery by means of the key and commutator.

The indices are maintained in the position in which they have been last placed by the **residual magnetism of the electro-magnets.**

Now, supposing it is necessary to send a negative current so as to work the index at the distant station, we must first press plunger K′, Fig. 50, which sets the commutator as shown in the figure. This places (Fig. 42) spring *a* in contact with *b*, *c* with *d*, and pressing the latter separates contact 3 (Fig. 53) from contact 4.

124. **The course of the current** may now be traced from Figs. 42, 43, and 44, as follows:—

Commencing from the positive pole of the battery,

to terminal P,
through the magnetizing coils M C^1, M C^2,
to terminal Q,
" " V,
" spring *b*,
" " *a*,
" terminal 9,

to terminal 10,
through the coils S S^1 actuating the red index,
to terminal 11, and thence to earth ;

and from the negative pole of the battery

To terminal Z,
„ spring *c*,
„ „ *d* and terminal 3,
„ terminal 2 and K B (on the key),
„ „ K A and terminal 1,
„ line.

Arriving at the next station it would enter at terminal 1, pass

to K A,
„ K B.
„ 2,
„ 3,
„ *d*,
„ 4,
„ 5,
through coils R R' (actuating the black indicator),
to 6,
„ 7,
„ relay coils (sounding gong),
„ 8,
„ earth,

and thus complete the circuit.

The relay would, at the same time, complete the local circuit by joining N to O ; *i.e.*, the current starting from the positive pole of the battery would pass

to P,
through the coils M C^1, M C^2,
to Q.
„ N,
„ relay armature,

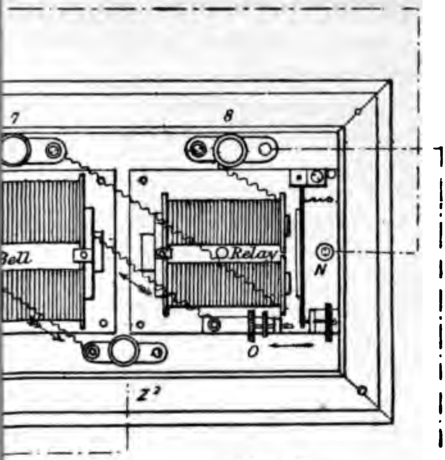


FIG. 43.

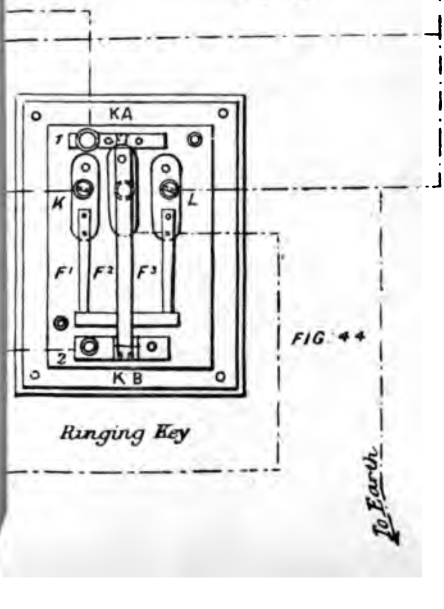


FIG. 44

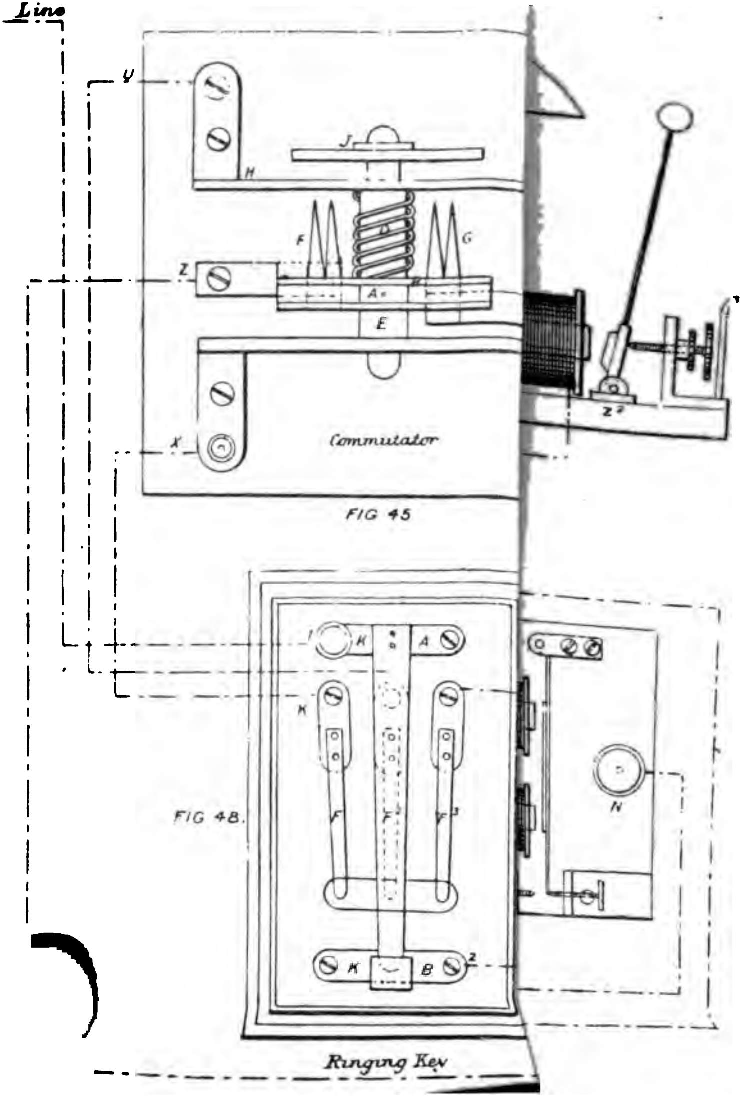


FIG 45

FIG 48.

to O,
„ bell coils (causing the hammer to strike the gong),
„ terminal Z^2,
and to negative pole of battery.

Thus, having pressed plunger K^1, we have—

I. Magnetized the cores of our own magnetizing coils M C^1, M C^2,

II. Moved our own red index.

Whilst at the distant station we have—

I. Moved the black index,

II. Completed the local circuit, sounded the gong, and magnetized the cores of coils M C^1, M C^2.

125. If, however, it is required **to sound the gong only, without altering the indicators,** instead of pressing plungers K^1 K^2, the ringing key only must be pressed.

To understand how this is effected it is first necessary to comprehend the action of the plungers on the commutator, which will be seen in detail by reference to Figs. 45 to 54.

A (Figs. 45 and 54) is a disc of insulating material, B and C are two pieces of metal on the upper side of it, C being also continued through to the lower side. B is connected with the upper part D of the insulated axle, and C with its lower part E (Fig. 51). Springs F and G (Figs. 50 and 52) are connected with the battery through the terminals Z and V, whilst the upper and lower bridge pieces H and I, in contact with D and E respectively, are connected with springs F^1 and F^2 of the ringing key (Figs. 45 and 48). By pressing plunger K^1, the stud L^1, Fig. 50, will press against the yoke J (Figs. 45 and 51), turning round the disc B C, and put F in contact with B, and G in contact with C. It will also (Fig. 53) disconnect 3 and 4. When K^1 is released, 3 will again come into

contact with 4, but F will still remain in contact with B, because there is nothing to bring the yoke J and the disc BC back. On the contrary (Fig. 51), the spiral spring around the axle D, and the two springs F G, tend to keep it in its place. Thus, according whether we press plunger K^1 or K^2, so shall we set the commutator

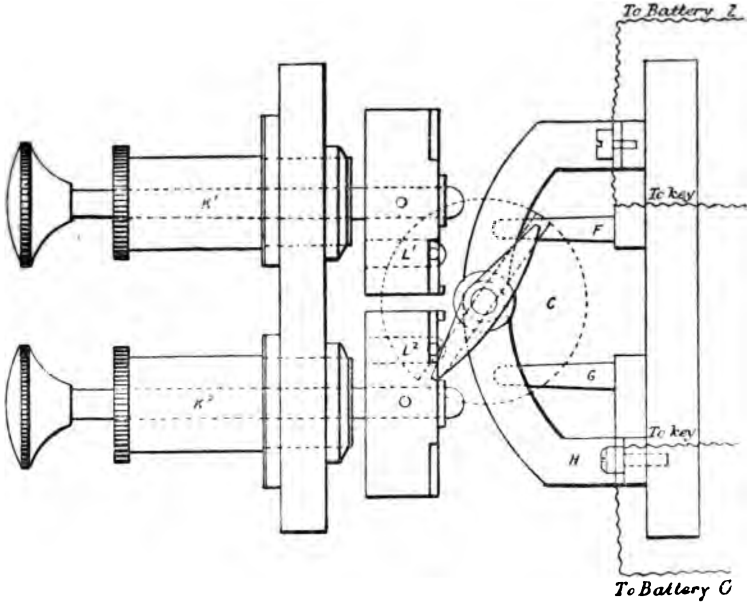


FIG. 50.

to send positive or negative currents upon the pressure of the ringing key.

Of this ringing key, Fig. 55 is an elevation, and Fig. 48 the plan; K A is the ordinary key plate in connection *with the* line, K B the contact from it to the instrument.

and W its plunger. Below the plate are three springs; F^3 connected to earth through the sending indicator coils, and F^1 and F^2 connected through H and I to the commutator. Thus when it is required to sound the bell or gong independently of the indices, on pressing down plunger W the key plate K A is joined to spring F^2, and spring F^1 is also joined to spring F^2.

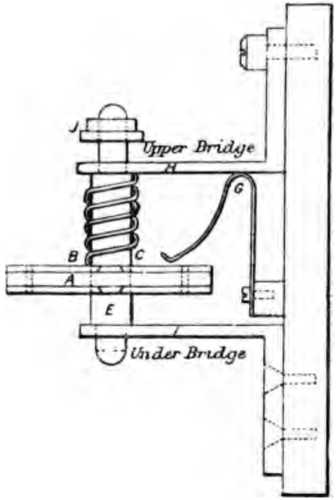


FIG. 51.

The current then traverses the following course; the commutator being set as shown in Fig. 45—*i.e.*, plunger K^1 having been last pressed.

From the positive pole of the battery—

to terminal P.

through the magnetizing coils $M C^1$, $M C^2$,

to Q,

to V,
„ spring G,
„ plate C of commutator,
„ pivot E,

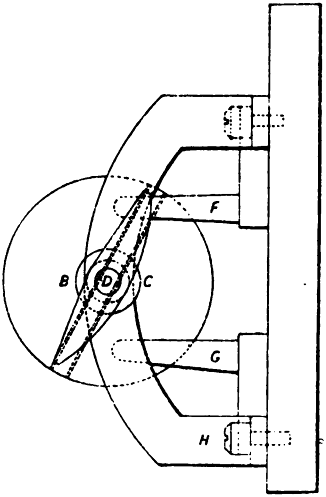


Fig. 52.

Fig. 53.

to bridge piece I,
„ terminal X,
„ „ K,

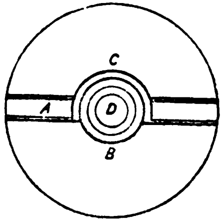


FIG. 54.

to spring F^1,
„ spring F^3,
„ terminal L,
„ earth.

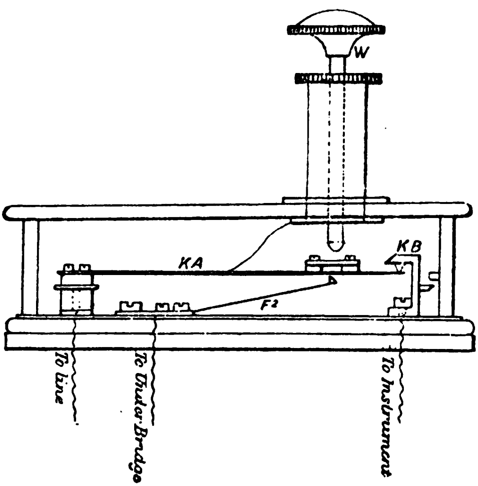


FIG. 55.

From the negative pole of the battery—

to terminal Z,
" spring F,
" plate B of commutator,
" pivot D,
" bridge piece H,
" terminal U,
" spring F^2 of key,
" K A,
and to line.

Arrived at the distant station, the current will traverse the course which was last set for it by the commutator there.

126. The **main feature of these instruments** lies in the coils connected with the indices (Fig. 46), and in the employment of what is termed residual magnetism. It will be seen that every time a current is either sent to or received from a distant station, a battery current must first pass through the coils MC^1, MC^2. The cores of these coils are not made in the usual way of the best annealed soft iron, but are of steel, which has the property of retaining any magnetism imparted to it until it dies out, is absorbed, or is driven out by a charge of an opposite character. To these steel cores are attached soft iron needles, which become magnetized by induction. Hence every current sent through the coils induces a polarity in the steel cores by which it is transmitted to the soft iron needles, according to the nature or direction of the current. The steel cores having thus become polarized retain the polarity acquired, until a current of an opposite character is sent through the coils, when the polarity acquired under it takes the place of the former. The needles are, therefore, always *charged* with either positive or negative magnetism at

their lower extremities, and will consequently be attracted to, or repelled from, the "horns" YY, $Y^1 Y^1$, attached to the cores of the electro-magnets, $R R^1$, $S S^1$.

Thus supposing the lower end of the needle to be always north, if a current be sent through the electro-magnet $R R^1$, in such a direction that R be made north and R^1 south, the needle will be repelled from R and attracted by R^1, and, on the current being reversed the needle will fly back to the opposite position. The lower needle which is also charged inductively by the local current, will be actuated in the same way by currents passing round the coils, $S S^1$. This accounts for the needles going over, and showing the direction of the currents sent through $S S^1$, or received through the coils $R R^1$.

The object of the horns YY, Y^1Y^1 is to concentrate and retain the residual magnetism.

127. A somewhat **later form of this instrument** is provided with a flap or shutter (Fig. 56), so constructed as to cover up either plunger of the instrument during the time it is not intended to be used; the object being to prevent the signalman **making use of the wrong plunger.** Another modification is that in which the ringing key is made to sever the line circuit from the indicating apparatus during its normal state, so that no current can enter the indicating coils without the action of the receiving signalman whose attention has thus to be first called upon the bell; whilst yet a further modification (Fig. 57) provides for an indication, showing "train in," or "train out," as the case may be. This latter form is used chiefly where the traffic is worked on the *affirmative* system—that is when the signals are nominally at "danger," and only lowered to the "clear" position on demand from the station from which the train is to come. The "train in" indicator is

worked by hand, but when turned to ***train in*** locks the "all clear" plunger, so that it cannot be used till the indicator is again set at "train out," which is done by the signalman on the train passing out of the station.

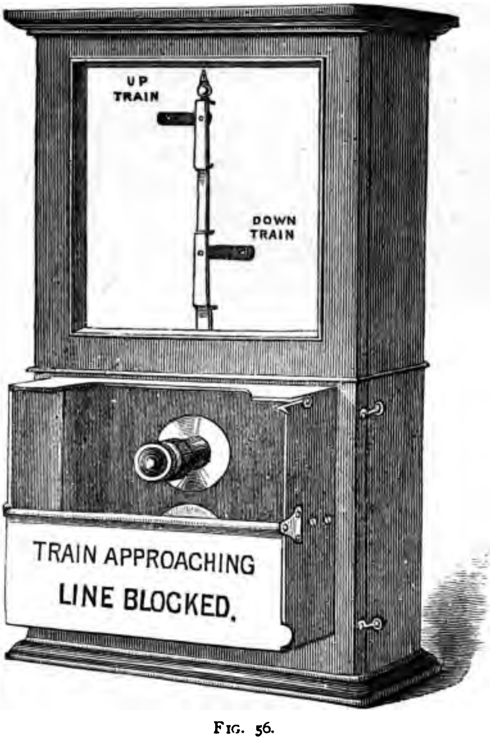


FIG. 56.

128. The **latest electrical arrangement** of Messrs. Tyers' instrument is shown in Figs. 58 and 59. *A, A, A*^{1}, A^1, are hollow cylinders; B, B, B^1, B^1, are deep

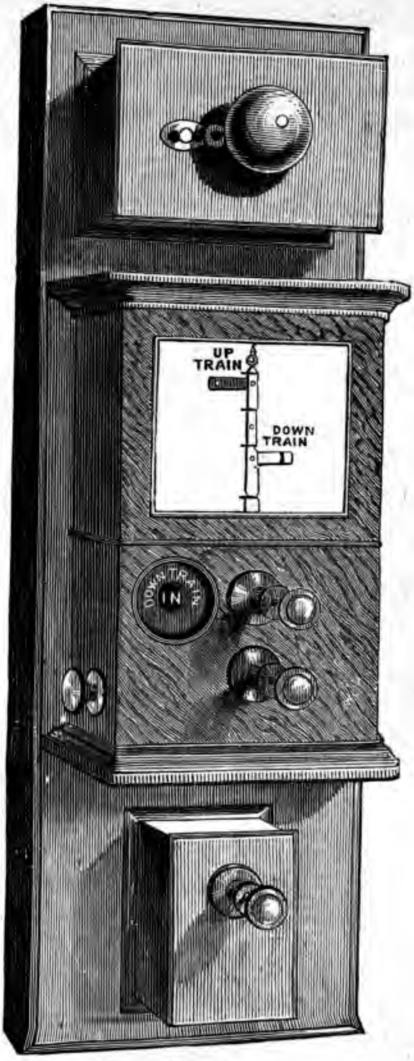


FIG. 57.

steps or notches; S, N, S^1, N^1, are the poles of the permanent magnets placed at right angles to the poles of the electro-magnets C, C, C^1, C^1. The poles of the permanent

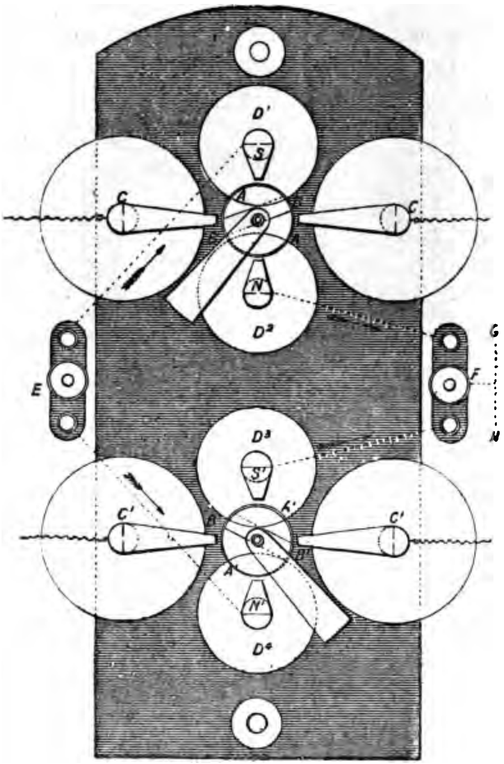


FIG. 58.

magnets S, N, S^1, N^1, are surrounded by coils of wire D^1, D^2, D^3, D^4, having their ends connected to the terminal,

plates E and F. The wire from the positive pole of the battery is attached to the terminal plate E, where the electric current divides and traverses the coils D^1, D^2,

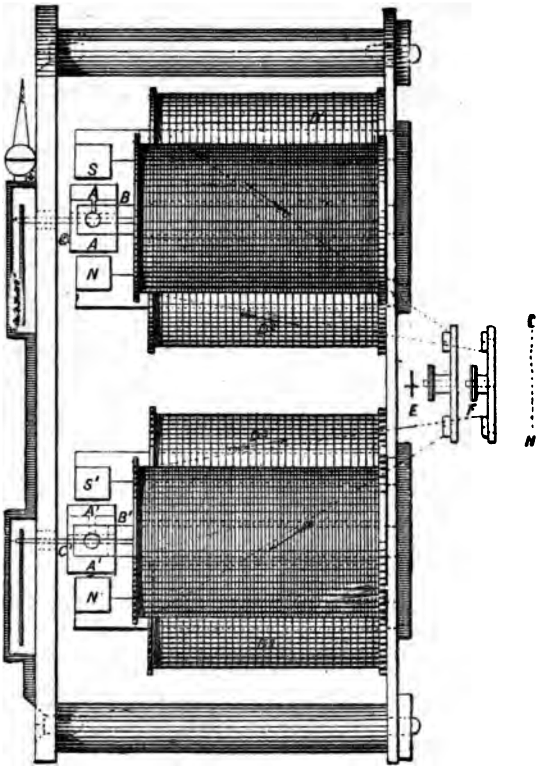


FIG. 59.

D^3, D^4, to the terminal plate F, thence by the wire G to a relay, and also by the wire H to the transmitting keys

of the apparatus. Thus no current cau be transmitted by such keys without first passing through the four coils surrounding the permanent magnets; neither can a signal be received from a distant station without passing through the relay that closes a local bell circuit through the same four coils. In both cases the permanent magnets are thereby kept replenished with magnetism to their fullest state of saturation, or to the extent of the battery power employed.

CHAPTER X.

SPAGNOLETTI'S BLOCK SIGNAL INSTRUMENT.

129. REJECTING the primitive method of using the ordinary needle pinned over to the right, or to the left, to indicate "line blocked" or "line clear," Mr. Spagnoletti affixes to the indicating needle a screen on which is printed the signal which the movement of the needle is intended to indicate. A square aperture is cut in the face of the instrument immediately in front of the needle, at which the screen carrying the signal $\left\{\begin{array}{c}\text{LINE}\\ \text{CLEAR}\end{array}\right\}$ or $\left\{\begin{array}{c}\text{TRAIN}\\ \text{ON}\\ \text{LINE}\end{array}\right\}$ is exhibited according to the direction of the current. But similar as is this arrangement, in principle, to the needle-block signal instrument, improvements in other respects accompany it, which claim for it an advanced position to that form of instrument.

Three wires are employed—one for each line, up or down, and one for the bell.

130. Fig. 60 is a front view of the block instrument. The "line clear" or "train on line" signal is given by pressing down one or other of the keys G, G^1, and keeping *it in that position* by means of a pin O, inserted through a

tube P, so as to intercept the upward movement of the key.

Each **key** has on its outer end a metal projection *g*, (Fig. 61) which is insulated from the key-lever. Underneath these projections is a spring *i*, *i*, stretch-

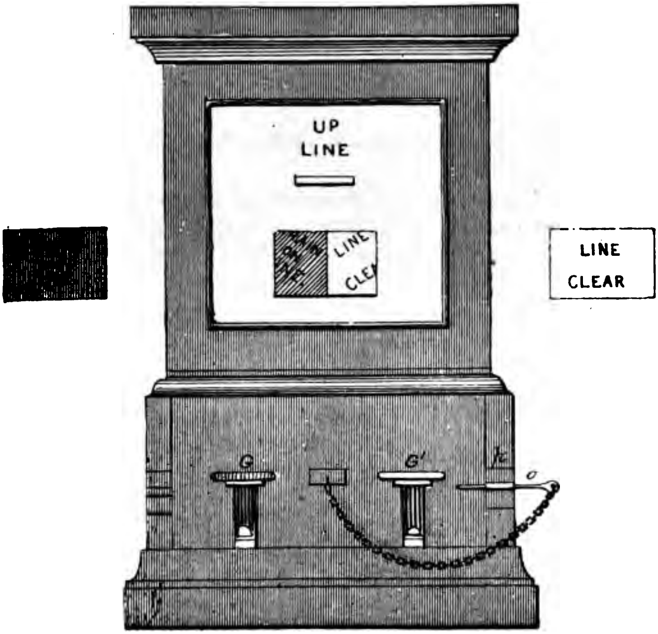


Fig. 60.

ing across the instrument, normally connecting the two cocks K, K^1. Upon depressing either key, the contact between K, or K^1, and the spring *i*, is broken; but *immediately* afterwards the spring seen below the lever

key (Fig. 63) is brought into contact with the stud l, or l^1, which is also in metal contact with the cock K, or K[1].

131. The **needle** by which the indicator is moved is magnetized by induction in the following manner.

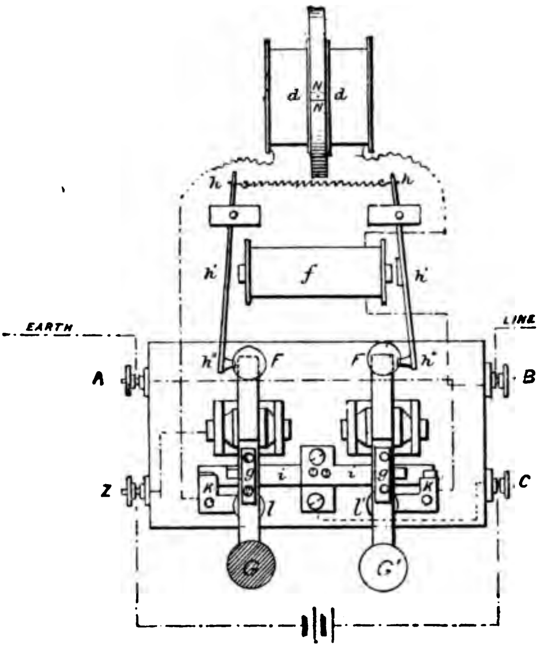


Fig. 61.

$n\ s$, $n^1\ s^1$ (Fig. 62), are two pieces of soft iron of the shape indicated in the drawing, coupled together by a piece of brass, or other non-magnetic metal at e, of which $n\ e\ s^1$, forms the spindle, and $s\ e\ n^1$ the needle working within the coils. C, C[1], are two permanent

magnets, of the horseshoe shape, arranged with their similar poles adjoining, from which the rectangular pieces $n\ s$, $n^1\ s^1$, acquire magnetic properties. D is the half coil. The permanent and the acquired polarity is that shown in the figure. The screen is affixed to the lower portion of the outer needle, the upward portion being weighted, as nearly as possible to counterbalance it. The shape of that portion of the induced needle, working within the coils, is shown by the smaller figure.

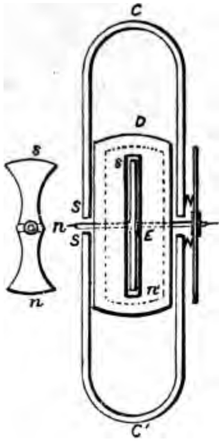


Fig. 62.

132. A **recent improvement** of the instrument embraces a means for preventing the signalman at one end of the circuit interrupting a signal given from the opposite end. Fig. 63 gives a side view, whilst Fig. 61 is also arranged to show that portion of the instrument to which this applies. f is an electro-magnet, fixed to the back of the instrument, but standing below the coils; h^1, h^1, are ar-

matures centred at *h*, to which are attached, by means of small wire rods, small brass blocks h^2. The armatures are coupled together at their upper extremities by means of a spiral spring, the tendency of which is to keep the blocks h^2 extended outwards, free from the back of the key and the cock F. Any current sent through the electro-magnet

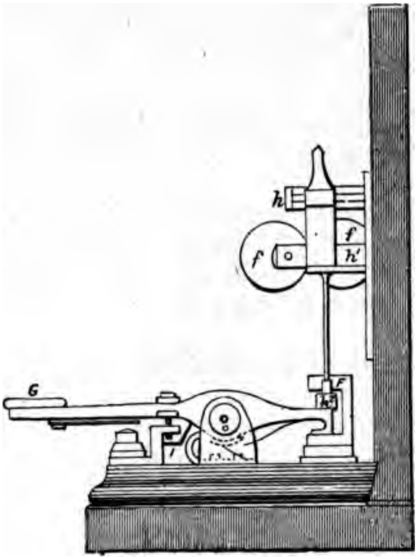


FIG. 63.

will attract the armatures, and bring the blocks h^2 between the top of the back part of the key G, and the lower portion of the cock *F*, which stands above it, after which it will be impossible to move the key G, so long as the current flows through the coil *f*, and the armatures *h* remain attracted. By this means all possibility of

contention between the men at either end is avoided, and any neutralization of signals from such a cause prevented.

133. The **electrical connections** are as follows. C, Z, are the battery connections; C is in connection with the plate, to which is attached the spring *i i*, and Z with the barrel of each key. The cock and stud K is in circuit with one of the indicator coils, the other coil being connected to the locking electro-magnet *f*, which is in circuit with terminal B. The connection between the cock K^1 and terminal A completes the circuit arrangements. A and B are the line terminals. Assuming that A is to earth and B to line, the current will take the following course:—

On pressing down the left-hand key the connection between *i* and K will be severed—the insulated cock *g* carrying the spring along with it in its downward progression. On G making contact with *l*, a current will flow

From the zinc pole of the battery—

to terminal Z,
" the axle of the key G,
" the stud or cock K,
" coils *d*,
" Electro-magnet *f*,
" terminal B,
" line.

Whilst the current from the copper pole will have passed

to terminal C,
" spring *i*,
" cock K^1,
" terminal A,
" earth.

The action of key G^1, as also the course of an incoming current, may, with equal readiness, be traced from the figure.

The pressure of the left-hand key gives the "train on line" signal; that of the right-hand the "line clear" signal.

The bell usually employed is that known as the "Tapper bell," which will be found fully described as we proceed.

CHAPTER XI.

PREECE'S SINGLE WIRE SYSTEM.

134. THE switch (§ 112), bell key (§ 114), and practically the same bell (§ 113) as is used in Mr. Preece's three-wire system are also employed in this. The semaphore (block) signal is, however, in this instance combined with the bell, the two being inclosed in one case, as shown in Fig. 64. The upper portion of the instrument is devoted to the bell arrangement, the indication of which is similar in its object to that of the three-wire system. The lower portion is the "block" signal.

135. The **main features of the system** are—the assimilation of the electrical to the outdoor or line system of signals; the record of the condition of the signal at the distant station; and the **impossibility of the all clear signal being recorded without the concurrent** action of the signalmen at both ends of the section.

136. The semaphore arm is worked from an induced magnet. The switch is employed as a commutator for reversing the battery current, and so arranging the current to produce the danger or "all clear" signal. The bell-key is that by which the indicating instruments are directly *operated.*

137. A A^1 (Figs. 65, 66) are electro-magnetic coils; B is the armature, fitted with a locking pin C and a spring E. F is a contact screw employed, in connection with the spring E, to operate the local circuit which serves the bell. P is a screw by which the tension of the spring

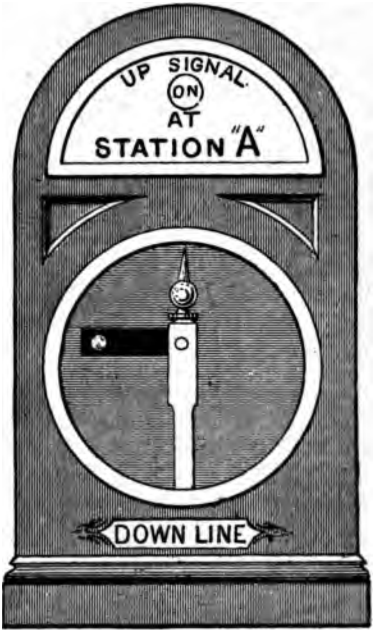


FIG. 64.

resting upon it may be regulated at pleasure, so as to insure a ready action on the part of the armature B. The work which this armature has to do is to lock or unlock the induced magnet which actuates the arm, and to open and close *the bell* circuit.

I is a small spindle, pivoted at Z Z[1], carrying at one end a soft iron needle G, so arranged that its lower extremity shall be free to move between the cores of the electro magnets; whilst its upper portion shall work in close proximity to the north pole of a permanent magnet H, more clearly shown in Fig. 67, whose south pole is bifurcated, one limb being connected with each of the cores of the coils. To the opposite extremity of the rod

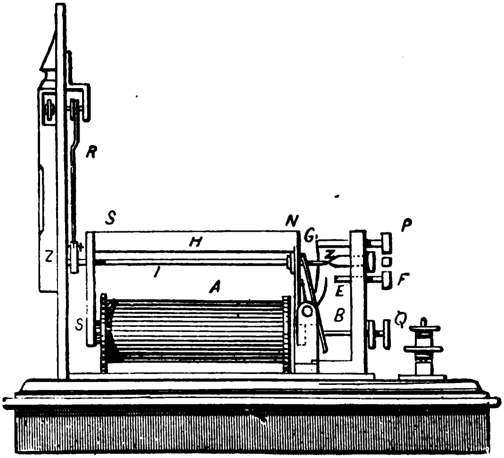


FIG 65.

I is attached a crank T (Fig. 68) which works within a slot R[1] forming the lower portion of the rod R, pivoted upon the snail-piece K, to which is also fixed the signal arm O. As a counterpoise to the arm, a small adjusting weight is arranged on that side of the spindle I opposite to the crank T.

138. Magnetism is induced in G, and in the cores of the *coils A A*[1], *by the* permanent magnet H. A positive

current passed through these coils would first attract the armature B, which would set free G, and complete the local circuit. G would then be drawn over to A^1, which

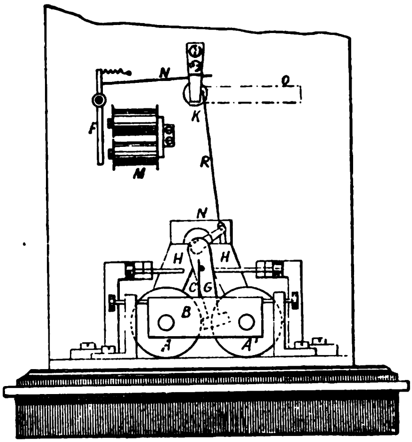


FIG. 66.

action would revolve the spindle I, and, raising the rod R, place the arm at *danger*. L (Fig. 68) is a small detent

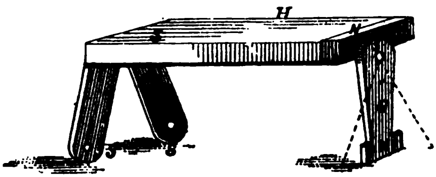


FIG. 67.

which rises with the arm until it drops over the shoulder of the snail-piece K, when it locks the arm to the danger

position. F is an armature having fixed to it, at right angles, a rod N, which when at rest is free of L, but which, on a current passing through M, and F becoming attracted, is raised sufficiently to lift L free of K. **To raise the arm** only one action is necessary, viz: that by which **a positive current is sent from the distant station.**

To lower it, however, there must be **concurrent action on the part of the signalmen at both ends of the section**; *i.e.* on the part of the signalman who sends, and on the part of the signal-

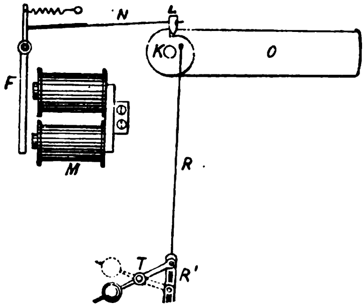


FIG. 68.

man who receives, the *clear* signal. The semaphore arm is kept in its danger position by either of two causes. It cannot drop so long as the detent L (Fig. 68) interlocks with K, and it cannot drop so long as the rod R remains in the position shown in the figure. The arm, once raised then, requires, first the lowering of the rod, and then the lifting up of L. Suppose now a negative current is sent from the distant station. It will pass through the semaphore coils, actuate the relay, and, *carrying G over to A,* will bring the crank T to the dotted

position shown in Fig. 68. The arm still remains at *danger*, held in that position by L. Only one step towards lowering it has been attained.

The second step is consequent upon the action of the signalman to whom the "all clear" signal has been sent. This "all clear" signal is accompanied by a specified number of beats on the bell. It is these beats on the bell which tell the man, that, so far as the distant station is concerned, the section between them is clear. It remains for the receiver of the signal to **acknowledge** it. This he does by pressing his bell-key and so sending a current to the distant station. Tracing this current by Fig. 69 we shall find it enter the instrument from the switch at number 4 terminal; thence it will pass by the plate of the instrument to the coils M, and to the bell-key by terminal number 3; whence, on the lever O of the bell-key being placed in contact with P, it passes to line, and so on to the distant station. In passing through the coils M (Fig. 68) the armature F will be attracted, and L raised, when the arm O, being deprived of its support, will fall to the *all clear* position. The outgoing current passes through the discharging coils M only at such times as the crank T is in the dotted position. At other times the coils M are short-circuited by means of a spring affixed to the spindle I for that purpose. **It is only when the "all clear" signal has been received from the distant station that the arrangement admits of the arm being lowered,** and this is then effected by the next signal sent in acknowledgment of it.

139. Fig. 69 shows the electrical arrangement of a complete set of instruments for working the up and down traffic of one end of a section. As already mentioned, the switch is here employed as a commutator to reverse

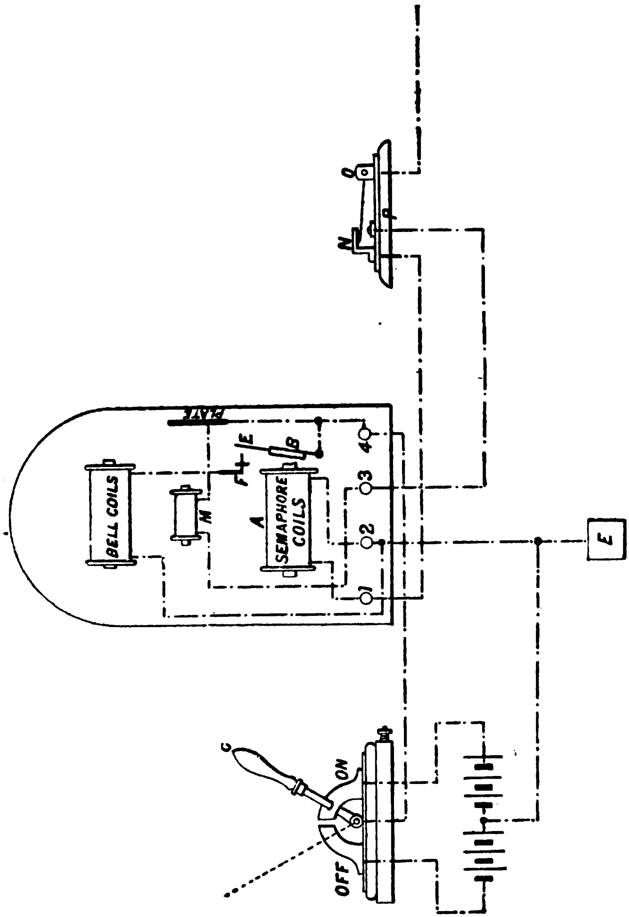


FIG. 69.

the battery current, the **danger** signal being produced by a positive, and the **all clear** signal by a negative current. The bell-key is the instrument by which all currents are transmitted to the distant station.

140. To send a danger signal the lever of the switch is placed at ON. Then on pressing the bell-key we bring its lever O, into contact with the lower stud P, and a current flows from the copper pole of the battery

to the ON segment of the switch—
„ the lever C of „
„ terminal 4 of block instrument,
„ the plate of „
„ discharging coils M,
„ terminal 3 of block instrument,
„ lower stud P of bell-key,
„ lever O of „
„ line;

and arriving at the distant station it enters at lever O of bell-key, and passes

to upper stud N of the same,
„ terminal 1 of block instrument,
through the semaphore coils A,
to terminal 2,
„ earth.

The opposite pole of the battery—the zinc—is direct to earth.

In passing through the coils A the current attracts B; G (Fig. 66) is set free and passes over to A^1, the rod R is raised, and the arm O placed at "danger."

The attraction of B to the coils A A^1, brings E into contact with F, and so completes the local circuit, one set of the sending batteries being brought into use, viz., that *with which* the lever of the switch is in circuit.

Assuming it to be with the ON (copper) set, a copper current will flow

to the ON segment of switch,—
,, lever C,
,, No. 4 terminal,
,, armature B,
,, spring E,
,, screw F,
,, bell-coils,
(the bell will be sounded and the index carried over to, or if already there, retained at, ON—causing the inscription on the face of the bell to read { SIGNAL ON AT STATION A }—
,, terminal 2,
,, earth.

Thus a *block* or *danger* signal has been sent from—say—station A to station B. At the latter station the arm has been raised and **locked at danger**; the bell has been sounded, and the bell indicator recorded the position of the arm at station A. If it were required to sound the bell any number of times, it would be for station A to press his bell-key a corresponding number of times; a current would follow the course just traced for each pressure. As regards the indicating portions of the instrument no change would take place, the only effect produced would be to confirm these in their positions and to sound the bell.

But now let the switch-handle, A, be reversed and placed at OFF, and let the bell-key at the distant station be again pressed. We shall then have a zinc or *negative* current flowing from station A to station B. It *will follow the* same course, and will attract the armature

B, as did the positive current; but here we find a change. The induced magnet G (Fig. 66) is now attracted to A: the negative current has polarized A A^1 in an opposite manner to that produced by the positive current last sent, and G is now repelled by A^1 and attracted by A. In passing to A, it lowers the crank T, but it does not lower the arm itself, which is held by the interlocking detent L, and **only on the acknowledgment** of the signal announced by the bell will the arm fall to the **all clear** position.

CHAPTER XII.

SIEMENS'S SYSTEM.

141. THE above system is not employed in England, but has been established on several continental lines. Its present improved form is shown in Fig. 70. The lower portion of the case is occupied by a magneto-inductor, from which the necessary current is obtained by turning the handle H. Thus when a signal is required to be sent it is necessary to turn this handle. No battery is needed, the inductor taking its place.

FIG. 70.

The protecting case is entirely of iron, and may be put in connection with the earth, should there be any fear that lightning may injure the signalman when working the apparatus.

The handle, H, of the inductor is at the right-hand side, and two plungers, A and B, are at the top of the protecting case. The signal plate "clear" is on white *ground,* and "blocked" on red ground, both apertures

being protected with strong glass covers, and each corresponding to one track, the direction in which the trains proceed being marked by arrows. A greater number of signal plates may, however, be combined with a single magneto-inductor at stations where there are branch lines, or more than two tracks.

The apparatus can be worked with only one wire for a double line of rails.

142. If the handle, H, of the instrument be turned, and at the same time the plunger A, at the left-hand side of the apparatus, pressed down, the word "clear" (which in the normal condition of the instrument appears at both apertures), changes into "blocked," thus showing the "up line" blocked, whilst the right-hand aperture would show the "down line" blocked, if the plunger B were pressed down.

When a signalman blocks his instrument in the manner described, the same operation causes the word "clear" to appear at the station immediately preceding; thus the signals of one station are always depending on the signals received from the stations on either side, so that if in the one station the signal "blocked" is visible, the signal "clear" appears at the station immediately preceding it.

Practically speaking the block signals inform the guard of the train whether the preceding train has reached the next signal station or not, thereby instructing him whether it is safe to proceed.

143. In order to prevent a signalman "clearing" the preceding block station before he has placed his own standard signal at "line blocked," Messrs. Siemens provide a winch, which in connection with the block apparatus is placed in any convenient position inside the signal-box (Fig. 71).

The mechanical combination between this winch and the standard signals is such that while the latter stands at line clear (placed so by means of the handle

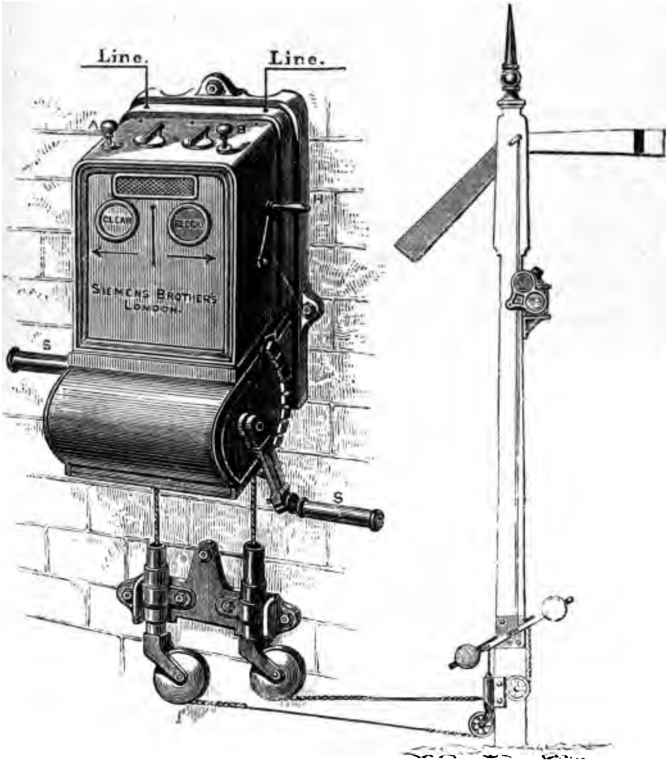


FIG. 71.

S, or a lever if preferred), it is *impossible* to give an electrical signal. In order to send an electrical signal *to the preceding* station (which is always the "clear"

signal) it is indispensable that the standard signal be first placed at "blocked."

An electrical clear signal sent to the preceding station during this "line blocked" position of the standard signal not only blocks the electrical apparatus, but also interlocks the standard "blocked" signal, so that the standard "clear" signal can only be given after the electrical "blocked" signal has been changed into "clear" by the forward station.

This winch is situated in an iron case underneath the block apparatus, and is provided with two handles, S S, corresponding with the "up" and "down" lines. By turning these handles right, or left, the corresponding standard signals are either raised or lowered. Should the semaphore arms only require a small force to work them, simple rollers or levers, instead of winches, are used.

These instruments are provided with or without alarum-bells, according to requirements.

The alarum-bells are not an essential part of the block apparatus, as it can be worked without their aid. Similarly, it can also be worked without placing the standard signals in dependence with the electrical signals.

144. **The working of the electrical block apparatus** is explained in the following:

Fig. 72 is a diagram representing two indices constituting one of the signalling instruments. As the two indices are alike it will suffice to describe the working parts of one marked I. R^1 is a movable arm, pivoted at z^1, and provided with teeth on its periphery. The movement of this index, "up" or "down," shows the signals "blocked" or "clear" through the aperture of the iron case, and this movement may be accompanied by the ringing of a

bell. The pallets of an escapement, a^1 (similar to the anchor escapement employed in clocks), engage in the teeth of the semaphore arm R^1. This escapement is attached to, and worked by the armature of an electro-magnet, E^1, and is caused to oscillate by a number of successive alternating positive and negative electrical currents. The arm R^1, by its own weight, has a tendency to fall in a downward direction, but being held by the pallets of the escapement, a^1, when they are at rest, it can only fall tooth by tooth when these pallets oscillate. Thus a number of successive alternating positive and negative currents are required to give a number of oscillations sufficient to change the signal; an accidental current, a succession of currents of the same direction, or a discharge of atmospheric electricity, cannot change the signal.

The armature, connected to the escapement a^1, is polarized, so that the alternating positive and negative currents transmitted through the coils of the magnet, E^1, cause it to oscillate. This oscillation, besides working the escapement, causes a hammer attached to the armature to strike the bells placed near it.

The arm R^1 shows the two signals, "blocked" on red ground, and "clear" on white ground.

In order to move the arm R^1 up again, a plunger, T^1, with a sliding weight, G^1, bearing upon the tail of the indices arm, R^1, is pressed down, thus giving the indices arm a tendency to rise, as soon as the armature a^1, oscillates.

This plunger, T^1, also acts upon a commutator, and determines the course the electrical currents have then to take.

The reciprocal operation between the block apparatus of two neighbouring stations may be understood from the following example:—

In Fig. 72 the "up line" stands at "blocked," a train

having just passed. As soon as that train passes the next station the signalman at that station presses down his "up line" plunger, and turns simultaneously the handle of his magneto-inductor. By these two operations he "blocks" his "up line" apparatus, and also sends alternately positive and negative currents along the line wire L^1, and through the conducting parts marked 1, 2, 3, 4, to the coils of E^1, and thence through 5, 6, 7, *VIII*, and *IX*, to earth, thus causing the escapement a^1 to oscillate. During this oscillation the arm R^1 descends, tooth by tooth, and brings before an aperture in the cover of the instrument the word "clear," while the word "blocked" becomes hidden behind the cover. A similar action takes place for the down line indicator, marked I I, when the currents are transmitted from a station towards L^2. Let us suppose a train on the down line has just passed. It is required to block the down line and free the preceding station. In order to do this the signalman presses down the plunger T^2, simultaneously turning the handle H of the magneto-inductor. The depression of the plunger T^2, interrupts the contacts between *I* and *II*, *VI* and VII, *VIII* and *IX*, but establishes contacts between *VI* and *X*, *II* and *XI*, and the alternating currents produced by turning the handle of the magneto-inductor will pass from earth through inductor *S* to *XI*, *II*, *III*, IV, through the electro-magnet E^2, to V, *VI*, *X*, over to I on the opposite side, through L^1 to the next station, which will receive the signal "clear" on the down line indicator.

The pressing down of the plunger T^2, besides acting upon the commutator, also brings the weight G^2 to bear upon the tail of R^2, and causes it to rise during the oscillation of its escapement, a^2, thus showing the word "blocked" in the aperture of the apparatus.

The action, therefore, of depressing the plunger T^2, and turning the handle H, removes the block signal from the preceding station, and at the same time shows it on the operator's own instrument, which block signal can only be removed by a similar operation at the *succeeding* station. The commutators therefore are so arranged that each instrument sends currents by the line opposite to that by which it receives currents.

145. **In order to transmit warning signals in a forward direction,** to announce the approach of a train (but without acting upon the ordinary signals), the inductor is provided with a contact maker, so arranged, that it will pass only positive *or* negative currents into the line, which act upon a warning bell at the forward block station. A separate key or plunger is placed between the line wire and the signalling instrument whereby the latter is cut out of the circuit, and the aforesaid single current contact maker brought into communication with the wire.

This arrangement is shown at Fig. 73.

P^1 and P^2 are the plungers or contact makers, the depression of which cuts either the up or the down index out of circuit, and brings the line wire of either side into direct communication with the magneto-inductor. The latter is so constructed, that of the two currents which are produced at each revolution of the bobbin, only one is permitted to enter the line. To obtain this result, the spindle of the revolving bobbin is for a short distance cut in half, one half being taken away and replaced by a piece of insulating material. One contact spring, x, is in communication with either terminal, p^1 or p^2, and receives the currents produced during half the revolutions of the bobbin, that is when *the spring x* bears against the metallic part of the

spindle. The contact spring $\pm$ is however in constant metallic contact with either line, *viâ* the springs s^1 or s^2, when the plungers T^1 or T^2 are pressed down. This latter contact spring $\pm$ therefore communicates both currents to either line. The currents of like kind passing by the spring x cause a bell to sound at the forward block station, thereby warning the signalman of the approach of a train. By pressing down the plunger P^1, these currents pass from the magneto-inductor into the up line L^1, and by pressing down P^2 into the down line L^2.

The course of the single currents being from earth through the magneto-inductor x, p^1, P^1, L^1 to the *forward* station, into P^2, M^2, s^1, W^2, through coils of up bell W^3, through bobbin of down line index to earth, the index will not be affected, but the bell will give any number of vibrating strokes corresponding to the manipulation of the magneto inductor.

146. An important extension of this system consists in **combining the electrical signalling instruments with the switches or other such apparatus,** as are usually employed for working the points and standard signals, whereby it is impossible to give electrical signals unless the standard signals are set at danger, and the points are in the required position.

This is accomplished by providing a cam and pawl in connection with the levers working the standard signals or points.

The pawl is moved by the plunger, which the attendant presses down when he works the electrical signalling instrument. It is held engaged in the notch by a detent, until by the working of the electrical instrument from the station beyond, the movement of the *electrical signal* releases the detent, and permits the

pawl to be disengaged from the cam by the action of a counter spring. When this is effected the point or signal is set free.

This arrangement is shown in Fig. 73. By turning one of the handles S^1 or S^2 the standard semaphore arms are moved up or down. When the arm is up or at "danger," the handle S^1 will press against the stop F. In this position a notch in a disc D which turns with the winch handle S^1, is brought to face a spring pawl, which if depressed, prevents the turning of the handle, and therewith the moving of the standard signal. Thus the depression of the plunger T^1 for giving electrical block signals is only possible when the standard signal stands horizontally, showing "danger." When the position of the winch handle S^1 permits the depression of the plunger T^1, the spring pawl is depressed and held down into the notch of the disc D by means of the rod G. The shoulder P fixed to the rod G descends, and permits the lever $L\ M\ N$ (which turns round the centre M, subject to the tension of the spring N) to take the position shown in respect of the up-line commutators to the left of the figure. If now alternating currents be sent by turning the inductor, the segment carrying the white and red discs ascends and shows, behind the aperture of the instrument cover, the "danger" or red disc. while at the same time the currents pass through line L^2 to the preceding station, and there remove the danger signal.

When the segment R has ascended, its axis (half of which is cut off) having turned, prevents the lever $L\ M\ N$ from returning. In consequence whereof, the shoulder P with the rod G cannot rise, and therefore the signalman cannot alter his standard signal as long as the *electrical index* shows the "danger" signal. If, however,

the signalman at the next or succeeding station removes this danger signal, then the segment *R* descending, brings the axis of *R* into such a position that the shoulder *P* gets clear of the lever *L M N*, permitting the rod *G* to ascend by means of the spring *r* being stronger than that of lever *L M N*.

In consequence thereof the pawl is withdrawn from the notch of the disc *D*, and the winch handle S^1, and standard signal are set free.

In this manner the standard signals and electrical signals are made to depend upon each other.

Fig. 74 shows a sliding bar *D*, by which the points are moved and interlocked by the electrical block signals,

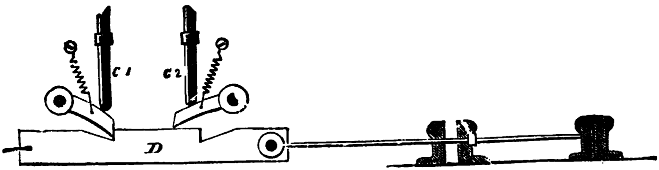


FIG. 74.

in the same manner as explained with the standard signals.

Such interlocking of electrical instruments with the points, or standard signals, can be modified so as to suit particular conditions in the working of sidings, junctions, &c.

CHAPTER XIII.

BLOCK SIGNALLING.

Definition of Terms.

147. By the term "**Block System,**" is meant :—

First. The division of the line into certain portions. **Each portion is termed a block, or section.**

Secondly. The method by which the traffic is regulated ; **so that only one train or engine shall be within any one "section" or "block," and upon the same line of rails, at one and the same time.**

148. The method of working electric block-signals has been divided under three heads, viz., the **positive,** the **affirmative,** and the **permissive.**

149. The **positive** system is that under which the section is blocked only during the time it is being traversed, or is occupied by a train.

150. The **affirmative** system is that which, maintaining the electric signals normally at "blocked," requires that the station in advance shall be asked, under a preconcerted bell-signal, "may train proceed" ; and in a similar manner to have this *affirmed* by a certain bell, or other signal before the train is allowed to proceed into *the section.*

151. The **permissive** system is really no *block* system at all. Under it two, or more trains travelling in the same direction are allowed within the same section at the same time; the second and following trains being cautioned as they pass the signal box that there is a train within the section, in advance of them.

Any such system is pernicious in the extreme, and cannot be too strongly condemned. Under it each driver is thrown upon his own responsibility, and whereas one may slacken speed and proceed at a moderate pace, another may be indifferent to the warning and continue his progress at the ordinary speed. Moreover, such a system cannot but be inducive of greater delay than if the sections were subdivided so as to accord more strictly with the requirements of the traffic, for the reason that it must lead to reduced speed.

152. The *positive* system is that most generally in use. It has this advantage over the *affirmative* system, that the instruments themselves show when a train is in the section, whereas under the latter system the "clear" signal is merely given to *admit* a train. Again, the out-door signals should, as a rule, be worked strictly in accordance with the indications of the electric signals. If these stand at clear, then the out-door signals should also stand at *clear*. If at blocked, then the out-door signals should also be at blocked, or *danger*. If the line signals are maintained at block when the section is not occupied by a train, it is impossible the danger indication can have that weight with the drivers that it would, were it employed to indicate danger only at such times as danger really exists. It is true that under each system a "train signal book," showing when each train is signalled in and out of the section, may be kept at hand for reference, still the "positive" system has not

K

only the book but the indication on the instrument for reference, and, as such, affords one more check upon forgetfulness or negligence.

It is not unusual to hear mention made of Tyers's system, Preece's system, Walker's system, &c., but when applied to the railway systems upon which such instruments are employed, the term is incorrect. Each maker or each inventor has a form of instrument, possessing certain characteristics, and applicable, in some cases, to a certain mode of working; but the form of instrument has very little, if anything, to do with the system, under which it is worked. For the manner in which the instruments are worked, the railway company alone is responsible; it is therefore the railway company's system, and should be recognized as such, and not under the name of the maker, or the inventor of the instruments employed.

153. Upon the **length and proper regulation of the sections,** depends the amount of traffic which may be worked over a line governed by a block-system.

Let fig. 75 represent a section of a railway system, of which A is the terminus, and B, C, junctions. The number of trains running out from A are at the rate of (say) twenty an hour. At B eight of these diverge for the branch E, and at C five diverge for the branch F. Now it is evident that to work this traffic without delay the sections between A and B must be such as to admit of each train passing through them within three minutes, and in order to provide against unpunctuality some margin should be allowed, so that it would only be safe to estimate the time of running at two minutes for each section. This at a speed of thirty miles an hour would give the length of each section as one mile. From B to *C trains* could be passed through at every five minutes.

but taking time tables and irregularities into consideration it would be advisable to reduce this to three minutes, which, at the speed previously mentioned, would call for sections of not more than one and a half miles in extent.

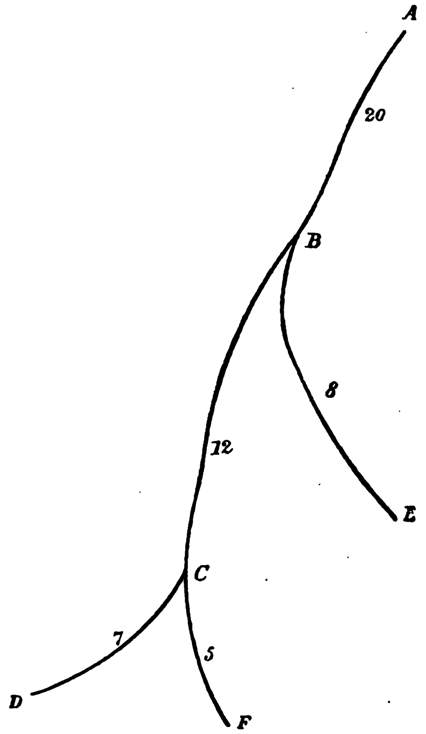


FIG. 75.

From C to D the number of trains is reduced to seven, which if equally dispersed throughout the hour would mean one train every 8·57 minutes. The farther we get

from the terminal station, however, the more irregular will become the intervals between train and train, and here the sections may fairly be regulated to four minutes in time, or two miles in length.

But, as a rule, the sections are to a great extent determined by existing circumstances such as stations, crossings, and junctions. At such points men must be kept, and advantage is usually taken of any such circumstances to establish at such points the required signal station, and so combine the duties of gatekeeper or pointsman with those of signalman.

Where a train is found to be habitually delayed at any one point it will be due to one of the three following causes. Either it does not keep time, is badly provided for in the time tables, so that there is not a sufficient interval between it and the preceding train, or that the section in advance of the point of detention is too long for the traffic passing over it. These are subjects which will demand the attention of the traffic superintendent, in whose hands they may generally be left with confidence as regards their speedy rectification.

Working Instructions.

154. Too much stress cannot be laid upon the necessity of well considering the instructions under which a block system shall be worked. Certain points of every system will require to be specially provided for, and the rules which will apply to one form of instrument will not be found, in all cases, to apply to others. So much depends upon the instructions under which a system is worked, that it is possible, under well-digested rules and regulations, to render an indifferent form of instrument as safe, or safer, for the regulation

of a service than would be the case with a superior form of instrument, worked under loose and ill-considered instructions.

In framing instructions, the working of the traffic should be considered under its most adverse circumstances, as for instance a snow-storm or a dense fog; and although it may be protected by other safeguards, the block-signalling instructions should, for the time, be regarded as forming in themselves the sole protection of the traffic. An important point to be borne in mind is the effect which the failure of a signal, or any portion of a signal, may produce. For instance, nothing could be more injudicious than to confirm the "all clear" signal by one beat of the bell, or to use one beat on the bell for that signal. Assuming, that with a system having an indicating signal—as a needle or semaphore—and a bell, the "all clear" signal was indicated by pointing the needle to the "all clear" side, or by lowering the semaphore arm to the all clear position, accompanied by one beat on the bell, and that the indicating portion of the apparatus failed and the signalling had to be carried on by the bell only, and that two beats on the bell indicated the "departure" signal; it is evident that if by careless signalling, or from any other cause, one beat of the departure signal is missed or lost, a very serious mistake may arise; for that which was intended to indicate the departure of a train from station A to station B, would reach B as the all clear signal, and if B had sent forward a train towards A, this imperfect departure signal would be to him the all clear signal for the train which he had sent on. A parallel case, unfortunately culminating in an accident, actually occurred in this way no great time since. The indicator was out of order,

the departure signal for one train was received at the adjoining cabin as the all clear signal: another train was sent in and came into collision with that which had preceded it, and which it was supposed had been signalled clear, but which was in reality being held by signal at the advanced station.

The errors which a disordered electrical apparatus may produce, or those which may result from negligent manipulation, are best known to the electrical engineer; and all instructions for working electrical block signals, placed under his charge, should have his careful consideration.

Although it is impossible to prescribe regulations applicable to every form of instrument, or such as would meet all the specialties of a railway service, the following observations may be found useful as generally applicable to the subject.

155. Every signal box should be provided with a "**Train Signal-book,**" in which should be entered all up and down trains under their respective columns; giving the description of train, the time it is signalled, the time the line is blocked, and the time it is again cleared. (See form in Appendix.)

For **single lines**, as the blocking will be in advance as well as in the rear of each train, double columns will be required. (See Appendix.)

For **junctions**, a special form, showing at a glance the signalling of each train, will also be found convenient.

All entries should be made direct into the book, and no erasures allowed. When an erroneous entry is made the pen should be drawn through it in such a manner as to show that it is crossed out, and yet not so as to obliterate it.

All **obstruction** signals should be duly recorded

after the following manner. The entry should be made under the line obstructed, whether the up or down. In the column for the description of train, the word "obstruction" should be entered, and under the column, "line blocked," the time at which the obstruction signal has been sent and acknowledged; and when the obstruction has again been removed, under the column "line cleared," the time at which the all clear signal has been sent.

When signalmen change duty, a line should be drawn across the book immediately beneath the last entry. The signalman going off duty should sign his name above this line, accompanied by the remark "off duty," with the time at which he hands things over to his successor, as "*C. Jones, off duty* 2.0 *p.m.*" The signalman who "takes on" should sign his name *under* the line with the remark, on duty at ———, as "*W. Williams, on duty,* 2.0 *p.m.*"

This **book should be inspected** by the station agent, the inspector, or other officer in charge of the signal-box, every day. It should be signed by him as a notification that he has inspected it, and taken note of any irregularities recorded by the signalmen for his information. When completed, the book should be stored away in the signal box, and never destroyed, except under directions from head-quarters.

156. **The block system should in no way cause those other and necessary precautions adopted for the protection of the traffic to be dispensed with or even relaxed.** Distant signals, hand signals, fog signals, and all other precautions should be as strenuously observed and enforced as though no block existed. The safety of railway traffic, or of any traffic where the responsibility is

necessarily of a divided character *is only to be secured by overlaying one precaution by another and duly enforcing the principle of each.* Thus when a train breaks down within a block section, the guard of the train might argue that he is perfectly secure, as the block at the box in his rear will be maintained till he arrives at that in advance; but his rules prescribe that he shall immediately go back, and by means of his flags, lamp, or fog signals protect the rear of his train. Again when a fog prevails, although the sections are sufficiently long to protect trains, it is yet necessary fog-men should be sent out, and that their instructions should be as carefully fulfilled as though the block were not in existence. It is by these checks upon checks, that any evil, which the remissness of the one individual is liable to produce, is to be averted. Their importance cannot be overestimated, and they should never be relaxed.

On single lines the block system must be subservient to the time tables; the crossing-places of trains should never be altered except under the direction of the officer whose special duty it is to attend to that imimportant function. At the same time the all-important object of the system, viz.: *to permit but one train to be in a section, on the same line of rails, at the same time, must ever be the paramount consideration of those working the signals.*

157. All **working instructions** should give a short description of the instruments to be employed, the mode of working them, and their object, so that those who have to work them may be conversant with their several uses.

Every train or engine should be signalled in its progress between station and station, or signal-box and signal-box, in accordance with a bell code, and the mode of working

the instruments, so as to produce the *blocked* and *clear* signals.

The **all clear** signal should not be given until the station at which a train has arrived *is actually clear and ready to receive another train on the same line.* Nor should it be given in any case until the *tail lamps* of passenger trains, and the *break van* of goods and ballast trains have been seen. This is to provide against danger in case of any portion of the train having broken away.

No second train or engine should be allowed to follow on the same line of rails until that previously in the section has been signalled clear of it.

On **single lines** no train or engine should be allowed to leave or pass a station or signal box, until the station or signal box **in advance has been blocked,** so as to prevent a train, coming from that direction, meeting that about to proceed towards it.

The **outdoor signals** should be worked in perfect consonance with the electric signals, except at junctions and other special points; and here any deviation from the general rule should be specified in writing.

Signalmen should be cautioned **when an electric signal stands at danger or blocked longer than is usual,** not to become nervous or over-anxious. The signal is before them. It says the line is blocked. Let them so regard it; and rather than suppose it is the result of negligence or error, *look upon it as a positive indication of danger to any following train.* It is at such moments that men are required to act with more than ordinary caution. Let them not therefore fear to stop any following train, or hesitate to hold any train which may be waiting to enter the section. It is better the train should be delayed than that risk and danger should be incurred. A signalman so placed should wait a reason-

able time, and if the signal still continues, then direct the attention of the signalman at the distant box to it by the *attention* signal, when, if the section is still blocked, the distant box will return the **obstruction** signal. Should no answer be received to a repeated inquiry, the signalman would be warranted in concluding the instrument out of order, and sending forward the waiting train under instruction to "proceed with caution to the next signal box, the block signals being out of order."

Should a **departure signal have been received, and the train not arrive within the usual time,** the signalman at the box at which it is due should immediately put on his outdoor signals *for trains proceeding in an opposite direction*, and only allow such to proceed under verbal caution, as possibly an accident, fouling both roads, may have occurred.

All shunting and crossing operations should be carried on under the block. Thus, for instance, station B has some waggons to cross over both roads. Before he does so he should see there is nothing coming towards him from either A or C, and this being so he should then give the "*obstruction*" signal to both stations, thereby blocking trains back at these points, and keeping them so until the roads are again clear when the "obstruction" should be removed, by giving to the stations obstructed the "all clear" signal. Anything which fouls a road is a source of danger to the traffic. The rules may forbid any shunting to be done during the approach of a train, but unless they go further than this and forbid it being done *only under the obstruction signal*, it *will* be done during the approach of trains. Moreover, without being thus protected the shunting is a positive source of danger, in that, although no train may have *been signalled*, a truck or a carriage may foul a point and

get off the road, and, before steps can be taken to stop a fast-speed train, it may not only pass the distant signal-box (which may be indicating the all clear signal), but be upon the cause of the obstruction before those engaged with it are aware. The very essence of block-signalling consists in keeping trains apart the space—whatever it may be—comprised within the section. If shunting is conducted simply under the protection of the station-signals, the danger which accompanies the presence of another train within the section exists, and the "block" becomes a farce.

Ballast trains should not be allowed to stop to load or unload materials between signal stations, without having first advised the signalman, and obtained his permission to do so.

Trains calling at **mineral sidings**, intermediate between signal boxes, should in like manner communicate with the signalman prior to entering the section. It may be that the train has to foul the opposite road, in which case it will be necessary to block trains in that direction till the crossing has been completed [the working of siding traffic will be found specially dealt with at p. 187.]

When a **speaking telegraph** exists between two signal stations, between which the regular block signals have failed, and it is desired to work the traffic under it; it should be worked only in accordance with *printed or written instructions*, and by *bona fide messages*—not by mere signals—as

SP.—Williams to Jones
A **B**

Number —— (giving the number of the train in the service time-tables) up, left **A** at 7.30 ; and on its

departure from **B,** after having been in like manner signalled to **C,** it should be signalled back, thus :—

SP.—Jones **B** to Williams **A**

Number —— up, clear at 7.35.

Until it has thus been signalled clear of the section, no other train should be permitted to follow.

All such signals should be recorded in the train signal-book, precisely as the signals are rendered, accompanied by a remark to the effect that the signal was rendered by speaking telegraph.

All **signals should be rendered as distinctly as possible,** free from undue haste, and perfectly free from temper. A passionate man makes a bad signalman. Signals are frequently made far too rapidly for the instruments to render them clear and unmistakable. For this there is no necessity: there is always ample time for all signalling purposes between the trains, and in the end it will be found that the man who does his work in a steady, methodical manner, will occupy less time in doing so than will an intemperate man, who, in a moment of irritation, works his instruments utterly regardless how the signals may reach his comrade, and totally unmindful of the importance of his work.

When signals are not acknowledged, they should be steadily repeated. No signal should be acknowledged unless it is *clearly rendered* and *properly understood.*

No signal should be regarded as complete until it is acknowledged.

158. Many **signals** are **rendered by the bell only;** that is, so many beats on the bell, unaccompanied *by any* movement of the indicating (block) signal. All

signals which embrace the movement of the indicator—from *clear* to *blocked*, or *vice versâ*—should be accompanied by a given number of beats on the bell, which should be regarded as forming part of the signal, and without which it should be held to be incomplete. Thus in giving the "all clear" signal, not only should the indicator—needle or semaphore arm—be placed at the "all clear" position, but the movement of it to this position should be accompanied by a certain number of beats on the bell appropriated to this signal.

The following is a **bell signal code** employed upon one of the principal English lines of railway. The letters placed against each signal have reference to the explanation of it which follows :—

1.	One beat	. . . .	Acknowledgment . .	**A**
2.	Two beats	. . . .	Departure signal for ordinary train . .	**B**
3.	Two "	given twice	Warning	**C**
4.	Three "	. . . .	All clear	**D**
5.	Four "	. . . .	Departure signals for .	**E**
6.	Five "	. . . .		
7.	Six "	. . . .	Obstruction	**F**
8.	Seven "	. . . .	Error	**G**
9.	Eight "	. . . .	Attention	**H**
10.	Nine "	. . . .	Testing	**I**
11.	Ten "	. . . .	Special attention . . (in advance.)	**K**
12.	Eleven "	. . . .	Special attention . . (in rear.)	**L**

All bell signals are given by pressing the bell key steadily and firmly a number of times, corresponding with the number of beats required to be rendered.

A. Acknowledgment.—Given in reply or

acknowledgment of a signal received. When it is required to follow up an acknowledgment signal by one of another character—as, for instance, a "departure" signal—care should be taken to make a distinct pause between the two signals, so that they may not be blended together, and thus be misunderstood as representing some other signal.

B. Departure signal.—To indicate the departure of a train or engine in ordinary course.

C. Warning signal.—Given to the next station in advance when the departure of a train is signalled from the station in the rear. Thus the station in advance has timely warning of the approach of a train, and if the section is "obstructed" has the opportunity of clearing it in time to prevent the approaching train from being checked.

D. The "all clear" signal.—Given only when the train has passed out clear of the section, or when an "obstruction" signal has been given, and the line thereafter is clear. It is used in conjunction with the lowering of the electric semaphore arm.

E. Departure signals.—Reserved for special purposes. The *four beats* are usually employed for denoting the departure of branch trains, so as to enable the junction signalman to set his points, &c., and to send forward the "warning" signal to the proper signal-box.

The *five beats* may be employed to distinguish *ballast* trains.

F. Obstruction signal.—This signal is given by placing the electric arm at *danger*, accompanying it by the six beats on the bell. It should be employed on all occasions when a section is "obstructed" from any cause whatever, and ought to be regarded in the **fullest** ***sense*** *as a* **danger** signal. On its receipt every effort

should be made to stop any train from proceeding in the direction obstructed, whether such train has been "warned" or not. At the same time care should be taken *not to acknowledge its receipt until the outdoor signals have been set at dauger and everything made sure against an approaching train.* The acknowledgment of it should be by six beats—a repetition of the bell signal itself—and should be held to indicate that the necessary steps *have* been taken to stop all traffic in that direction.

G. Error signal.—Given when an erroneous signal has been sent. It cancels the signal previously sent. Thus, supposing a train has been signalled to a junction as a main line instead of a branch train: the junction signalman will have, in the ordinary course, "warned" it forward to the next main line station. On the approach of the train, he discovers by its head lights, or the arrangement of its discs, that it is not a main line, but a branch train. He therefore sends the "error" signal to the main line signal-station, and thereby cancels the former signal. The signal is again useful for cancelling a "warning" sent forward for a goods train when such train may perhaps have work to do at a station which will occupy it some time.

H. Attention signal.—Used to call attention when a signal has not been acknowledged, or to any unusual continuance of the block.

I. Testing signal.—Indicating that the signals made are for the purpose of testing the instruments. A certain system should be pursued when making these tests, so that there may be no possibility of such being mistaken for *train signals* of any description. Moreover instruments should never be tested during the time trains are being signalled by them, or are traversing the section.

It is a signal which should be used only by the telegraph inspector, line-man, or other authorised official.

K. Special attention or stop signal for the station in advance.—This is a most important signal, and indicates something noticed wrong in a passing train— as for instance a portion of the train missing, a tail-light out, a door open, or anything which might render it desirable to stop such train as speedily as possible. The station receiving such a signal should at once place his home and distant signal, for trains approaching from the direction in which the signal has been received, at *danger*, and on the arrival of the train advise the guard and driver of the signal received. Where a speaking telegraph exists between the points, the signal should be confirmed by a message giving particulars of what has been noticed to be wrong in the passing train.

L. Special attention signal for station in rear.—This is equally important, and is used to indicate to the station in the rear of a passing train that some portion of the train has been noticed to be wanting. It should be acknowledged by repeating the number of beats comprising the signal, and the signalman receiving such a signal should take immediate measures to secure the safety of the road, especially if the gradient be a falling one, and should stop any following train and warn it of the impending danger.

In framing a code of bell signals it is better first to draw out a list of the signals required to be used. To then arrange them in their order, appropriating the lesser number of beats to those likely to be most in requisition ; being above all things careful that the "all clear" signal is not so formed that it can be produced by any foreign current—as contact or lightning.

No **private signals** should be permitted on any description of block-signal instrument.

It should be the duty of the station agent or inspector to see that a competent person is always in the signal-box half-an-hour before the arrival or departure of the first train, and no release from duty should be allowed till the "all clear" signal for the last train signalled has been received and entered in the train signal-book.

At certain stations where the duties are light and where the stopping traffic ceases at a comparatively early hour, switches (p. 241) are sometimes used for cutting the signal instruments of that station out of circuit, and placing the boxes on either side in direct communication with each other. Where this is so a special signal called the **switch signal** should be authorised in writing, the instruction being precise as to when the signals may be cut out of circuit—a clear time, *i.e.*, when no trains are being signalled, being usually selected for the purpose. The signal may be the same for "opening" as for "closing" the box; the one being in the morning and the other at night no confusion is likely to arise. Three times three strokes on the bell, given thus—

. . .   .

the dots representing the bell strokes, and the space between the interval of time between them, would serve the purpose.

If a train is in transit at the time the switch is opened, the signalman should not give the line clear signal until the train has passed the switch station, or line clear has been signalled from that end of the section towards which the train is travelling.

Where **goods traffic intermingles** to a great extent **with passenger trains** it is advisable to

include in the bell code, a signal which shall indicate that the goods train then in the section is to be *shunted* for a following passenger train.

159. When the **block-signal instruments are out of order,** information to that effect should be sent, as speedily as possible, to the lineman or other authorised officer.

It is a good plan, **where no means exist of telegraphing to the proper quarter,** to make use of a **black-board,** which should be, on such occasions, exposed to the view of passing trains, the drivers of which should be required to report the fact to the next station from which the subject can be telegraphed.

When the block signals fail entirely and there exists no speaking telegraph between box and box, it becomes necessary to stop all trains and verbally caution the drivers to "proceed with caution as the block is out of order."

160. On some railway systems a **speaking telegraph** is provided **between the signal boxes.** Its object is to enable the signalmen and others to make inquiries respecting the running of the trains, and to form a reserve means of working the traffic in case of failure of the block-signal instruments.

The provision of a speaking telegraph for such purposes is no doubt convenient, but it is questionable if it is, in all cases, desirable. At stations where much shunting has to be performed it is an advantage, but in all such cases the communication should be with the traffic people—the station-agents, or superintendent's offices—and not with the signal-boxes. Unless there is an absolute necessity for it, for purposes independent of the *block signalling,* it is not desirable. It introduces laxity

on the part of those whose duty it is to keep the block signals in good order, and it is not inducive of that exactitude in dealing with the block signals so desirable on the part of the signalman; because, in both cases, the speaking telegraph stands in reserve. Where no speaking telegraph exists the men know they have but the block signals to rely on; hence the duties devolving upon the latter are likely to be the more faithfully performed.

161. **No strangers, nor officials off duty should be admitted to the signal-boxes.**—Under no circumstances should any person be permitted to interfere with, or to engage the attention of, the signalman on duty.

162. The **batteries** should be kept in a closet specially provided for that purpose. No rubbish, books, or other matter should be placed upon them. It is by such means the wires become broken or disconnected. During very cold weather, hand, or other covered lamps should be kept burning within the closets in order to prevent the liquid in the batteries becoming frozen, and so rendering them inoperative.

Arrangement of Instruments.

163. **The manner in which block-signal instruments should be arranged** and fixed for use in a signal-box is a matter of more importance than would appear without due consideration. The duties of a signalman are onerous; his attention should always be on the alert. At busy points he knows not from one moment to another when he may be called on to obstruct the line—to place his signals at danger. An instant of time may be all-important. His duty is to watch for the

approach and departure of trains, and to protect them by the means placed at his disposal for that purpose. To enable him to do this his signal-box is usually so built and so arranged that, standing at his frame, ready to handle his levers, he may have a full view, up and down, of the lines he is required to work. It is evident that there is a purpose in this, and the purpose is that the man's attention shall not be diverted from his frame, or from the view which he obtains from the position in which it is placed.

His outdoor signals are worked by—that is, in accordance with—his electric signals. Now if the latter are arranged, as is frequently the case, on a counter at the back of the box, it is clear that when the signalman is attending to his frame his back is towards his block signal instruments; and when he is attending to his block signals, he is away from his frame, and probably away from the view which he ought to have of his roads. It is evident then that his **block signals should be arranged in such a manner that he may be able to work them, and to have a full view of them, without leaving his frame.**

It is to be regretted that the majority of the signal instruments in use are scarcely, in their present form, fitted for this. The needle forms are bulky and awkward to work from such a position. Spagnoletti's are not so bulky, but the tapper arrangement is not convenient for use over a man's levers. Tyer's is more convenient from the mode of working the plungers, but the instrument is large, and when arranged in front of the frame is destructive of the signalman's view. Only Walker's and Preece's are really applicable to this requirement.

In both these forms we have the indicating (block) *instrument* independent of the signalling portion. With

Walker's the signalling is managed solely by means of a double key—two plungers, one for blocked, the other for clear. These may, with convenience, be fixed immediately over the lever handles, so that they may be operated by the signalman at the moment he is operating

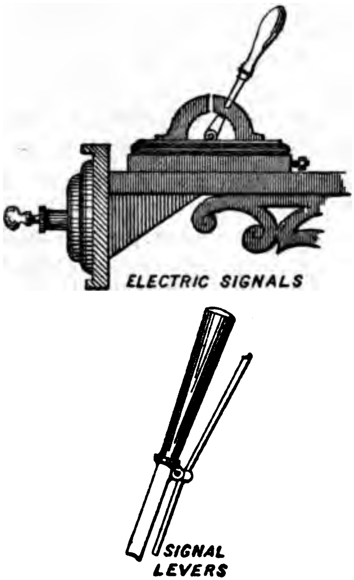


FIG. 76.

his levers, whilst the indicating portions may be placed at either end of the frame according to the roads they protect or represent.

The system advocated is that invariably pursued by the London and South-Western Railway, and no form of instrument is so thoroughly fitted for the purpose as that

employed, viz., that designed by Mr. Preece. Every portion of the apparatus is before the signalman; those portions he requires to use, the bell key (§ 114), and the switch (§ 112), are arranged on a shelf with a face to it, a side view of which is given in Fig. 76. The bell keys are placed on the facing board, the switches on the shelf. The bells are arranged on a shelf some eighteen inches above, and the semaphore (block) instruments at either end of the frame, that for the up road on the up side of the frame, and that for the down on the down side, as shown in Fig. 35a, p. 77. With the bells and semaphores the signalman has nothing to do in the way of manipulation; all he requires to touch are the switches and the bell keys, and these are thus ready at his hand.

There would appear to be no reason why the manipulating portion of the needle, and indeed of all other systems, should not be made separate from the indicating portions, and fixed in a similarly convenient manner before the operator; and for reasons which will be referred to hereafter (*vide* Junction Working, chap. xv.), this course is rendered still more desirable.

Supervision.

164. Although all branches of a railway service are important, it is probable none are more so than that appertaining to the signals. Under it the traffic of the line is conducted, and any looseness which may be allowed to creep in at once becomes a source of danger.

Every signal-box should be under the immediate charge of the station agent, whose duty it should be to see to its staff arrangements, its cleanliness and order, to examine the train signal-book, the method of conducting *the signalling to* check the time so that there may be as

little variation as possible in that of one box with that of another, to examine the locking and see that the points and signals are properly adjusted and working satisfactorily.

In addition, there should be a frequent periodical, inspection of all signal stations by an officer competent to judge of all these matters, and to consider and deal with any suggestions having reference to the working of the traffic which the men may offer. Under his inspection the time at the one box would be compared with that at the next. The manner in which both the electric and outdoor signalling is carried on, the train signal-book, the locking, the appearance, order, and cleanliness of the signal-box, the comfort and cleanliness of the men, the detention of trains,—are all matters which would naturally obtain his consideration, and, where necessary, form subjects for report to his chief.

Considerations on the Requirements of Block Signal Instruments.

165. All forms of **speaking instruments are undesirable** as block-signal instruments, for the reason that the instrument being available for conversational purposes may be used for such a purpose when required for block signalling, and because the indications rendered by such systems are not so evident, and do not possess so distinctive a character, as do those of instruments made specially for the purpose.

Every block-signal instrument may be considered as a **distant stop signal.**

But two indications are required, viz., **blocked** and **clear.**

The **blocked** and **clear** signals should be **visible,** and **confirmed by a bell signal.**

The agency by which the CLEAR signal is produced should be active during the time such signal is required to be rendered.

This is only obtainable where a wire is devoted solely to each indicating signal. It is evident that one-wire systems do not admit of this, as upon that wire all signals, whether for moving the indicator or ringing the bell, have to pass. If the wire is occupied by a constant current of electricity it is clear no other current, of such a character as is required for other than the clear signal, can be sent through it.

Hence three-wire systems, where worked upon the constant current principle, are more reliable than single-wire systems.

The **danger** signal may be produced by **gravity.**

It is preferable that any **derangement of the wires or apparatus** should produce the **danger** than the **clear** signal.

In no case should the signalman at the station at which the *blocked* or *clear* signals are shown, be able to **alter** or **reverse** such signals. They should always be under the control of the signalman **in the direction in which the train is proceeding.**

A **record or repetition** of the condition—whether at *danger* or *clear*—of the block signal at the distant station is **highly necessary.** It inspires confidence in, and acts as a check upon, those who have to work the instruments, besides being to them a means of reference at any moment.

It is better that this repetition should be obtained **automatically from the distant block-signal instrument itself.** Failing this, it should be the **result of a signal from that station;** not merely the record of the outgoing current of the station

requiring the repetition. There is no reliability in the latter; the line wire may be to *earth*, and so long as the current leaves the sending station the assumed repetition will be produced on the instrument although the current will not have reached the distant station.

In single-wire systems it should be impossible, after the instrument has shown the **blocked,** for it to show the **clear** signal, **except by the joint action of the signalmen at either end of the section.**

No system in which the clear signal can be produced by lightning or contact is safe.

There is an advantage in **assimilating the form and method of working the electric to the outdoor system of signals.** The working of them is more readily understood by those to whom this duty is intrusted. It forms in fact but a repetition, the one of the other.

In no case should the means by which the *blocked* and *clear* signals are produced **be so similar as to admit of the wrong signal being sent** in moments of emergency, excitement, or haste.

At junctions and sidings that portion of the apparatus by which the *blocked* and *clear* signals are given **should interlock, so that any section which may be fouled by an approaching train shall be blocked before the clear signal for such approaching train can be given.**

The system should be such as to admit of all **draw-bridges,** or **other movable portions of the line, placing the signals for the section disturbed, at danger, automatically.**

CHAPTER XIV.

AUTOMATIC BLOCK SIGNALLING.

166. THE idea of operating fixed signals which should govern railway traffic, by the trains themselves, either directly or indirectly, mechanically, or by the aid of electricity is by no means of recent date. In 1862 letters patent were granted to Mr. John Imray for "improvements in apparatus for telegraphing and signalling by means of electricity." He proposed to mount on the column of the distant signal a vane, disc, arm, or coloured light, which, when turned in one direction, should indicate line clear, and when turned partly round in another position should indicate line blocked. For this purpose he employed clockwork, actuated by a spring or weight which had to be kept constantly wound up and ready to turn the signal or light when released by a detent; the detent being acted on by electro-magnetic apparatus worked either by hand, as from a station or junction, or by a treadle laid in proximity to, and parallel with the railway metals.

The disc revolved in quarter sections, and when in that position in which its whole surface was presented to the approaching train represented *danger*, and when *exhibiting* its edge only, *all clear*. In combination with

this arrangement bells were fixed at the station or elsewhere which were set ringing by the current employed to put the signal on, and which continued to ring until the signal assumed the danger position, when the movement of the signal interrupted the circuit and so stopped the ringing of the bells. Miniature vanes were also to be provided at the station or place from which the signal was worked, which were, by the action which caused the ringing of the bells to cease, turned to a position corresponding with that of the distant signals which they represented.

The same specification further embraced a means for indicating at a railway station the progress of trains approaching, or departing from it. At various distances along the line instruments were fixed which, when acted upon by the passing train, made or broke contact, and so brought into action an electro-magnet, by which an index fixed at the station was caused to move forward one step for each current sent.

167. A system of automatic signals has recently been brought into use on the New York Central Railway which in principle is very similar to that referred to as emanating from Mr. Imray.

168. The signal employed is of the disc description, and is inclosed in a case encircled by a shield A as shown in Figs. 77, 78; the former of which gives a front, and the latter, a side view of the same. The shield A is coloured white both front and back. D is a circular aperture, protected with glass, through which is seen the disc which forms the signal. The back of the case or box is also protected with glass. Thus, when the internal disc stands parallel with the outer shield, the aperture is filled up, and when it stands crossways its edge only is to be seen and the aperture consequently

appears vacant. The former position gives the *danger* signal, the latter the *all clear* signal.

169. Fig. 79 is a representation of the internal arrangement inclosed in the box B. DD is a broad circle of metal painted red, inclosing a disc of similarly-coloured glass, the whole of which is rotated *in one direction only* by the clockwork below, and which in its turn is propelled by the weight E. Upon the shaft carrying the signal disc, are four arms F^1, F^2, F^3, F^4, having downward projections as shown in the figure. G is an electro-

FIG. 77.

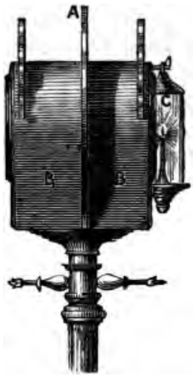


FIG. 78.

magnet fixed to the framework H, the armature of which is provided with a stop-block or catch-piece, so that when the electro-magnet is not in action and the armature is at rest, the stop-block may catch the projections F and prevent the rotation of the disc, which would otherwise take place under the influence of the weight E. Attached to the shaft just below the point at which the arms F are fixed, is a metal cam, having two metal studs, and having metallic circuit with the framework. I is a

circular stage, on which is fixed two insulated metal springs, so that when DD stands at *danger*, one of the springs shall be in contact with one of the studs whilst the other is free; and when the signal is in the *all clear* position the other spring shall be in circuit with the other stud, whilst the spring and stud formerly in contact shall be free. Let one of these springs—the former—be

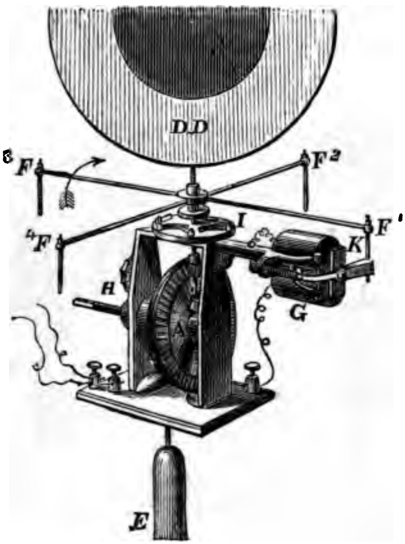


FIG. 79.

termed the "all clear" spring, and the latter the "danger" spring, because, as will be seen hereafter they are connected with wires required to produce those indications.

The post upon which the signal is fixed is usually of metal, and is hollow, so as to admit of the passing up and down of the weight, within it. In order to insure due

action on the part of the machinery, it is incumbent on the signalman to wind up the weight, by which it is operated, before he can open the door at the back of the case B to insert his lamp for the night signals.

170. Fig. 80 represents a vertical central section of

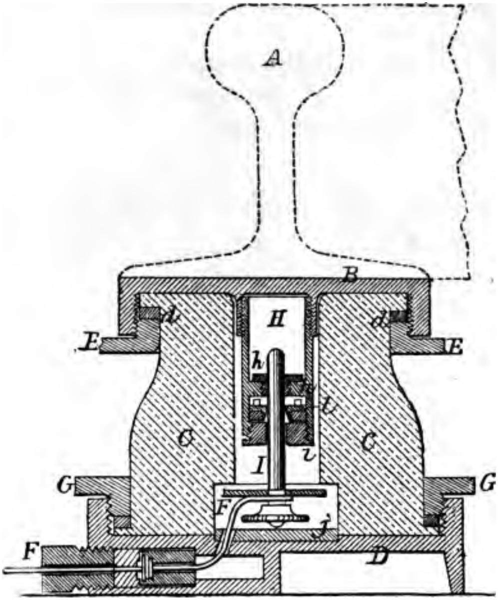


FIG. 80.

the commutator, or circuit closer, in its normal state. Fig. 81 is a similar representation of the same when in action, that is, when pressed down by the weight of a passing train. A is the railroad metal, B a metal plate in contact with it upon which the metal rests. C is a *hollow cushion* of india-rubber, flanged at its upper and

lower ends, and held in its place by the bed-plate D, and check screws E and G, between which and the flange of the cushion is a washer *d*. H is a metal tube in connection with the plate B, carrying within it a hollow plate *h*, which is in metallic connection with the body of the tube; *i* is a screw ring of india-rubber, and *j* a disc of the same material, upon which rests the rod I, to which is attached the line wire F. Within the hollow plate *h* is fitted an india-rubber washer, and resting upon the rubber ring, *i*, are two semi-circular pieces of metal, held firmly against the pin I by the rubber ring with which they are

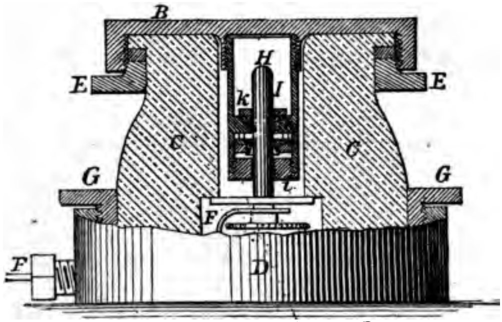


FIG. 81.

packed. To these semicircular pieces are fitted contact studs, the arrangement being such that the pin I shall be free to pass through K, but that the friction of the metal plates *l*, caused by the action of the india-rubber ring, which presses them closely upon I, shall be such as to enable the latter to carry them along with it, or to keep them stationary whilst the plate *h* is pressed down upon them. When this is so the connection between the line wire F and the earth, by way of the metal tube H, the metal top B, and the rail is established.

171. These commutators are fixed at the beginning and end of every section. Two are required, one for the *block* or *danger* signal, the other for the *all clear* signal. The former is placed some two hundred yards in front of the signal, so that the driver may see the signal is operated

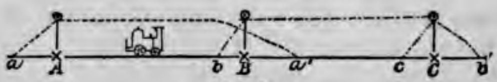


FIG. 82.

as he passes it; the latter, a similar distance beyond the signal. Let A, B, C, Fig. 82, be three signals such as have been described, *a* will be the commutator by which A is placed at danger; *b* that by which B is placed at

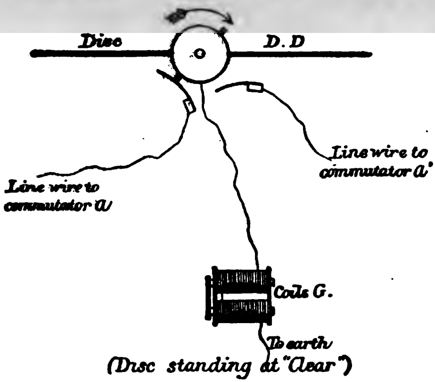


FIG. 83.

danger; then comes the signal B, and after that another commutator *a'*. It is by *a'* the signal A is set at clear, *c* is that which puts C at danger, and *b'* that by which B is again set to clear. Each commutator is connected *with its signal*, as shown by the dotted lines.

172. Let us now trace the course of a train through the two sections A B, B C. The wire connections of the commutators are as follows:—from *a* to the "danger" spring, Fig. 83, of the signal A; from *b* and *c*, to the same springs of signals B, C, respectively; and from *a'* and *b'*, to the "clear" springs of signals A and B. We now start our train, and it passes commutator *a*, and by its weight the electrical action between *h* and *i*, Figs. 80 and 81, is completed. A current now flows from the battery along the battery wire, through the coils G (Fig. 79)—

to the iron frame H.
 "danger" spring.
 line wire.
 pin I.
,, semicircular pieces *l*.
,, plate *h*.
,, plate B.
,, rail and earth.

} Figs. 80 and 81.

The armature K is attracted, the pendant arm F^1 released, and under the influence of the weight E, the disc is set in motion in the direction indicated by the arrow, Fig. 83. No sooner, however, does this motion take place, and the arm F' pass the catch-piece of the armature, than the "danger" spring is carried away from the stud on the cam below the junction of the four arms F; and the line wire in connection with the commutator *a* is now no longer in circuit with the coils G. The disc makes its quarter revolution. The signal stands at danger, and in that position is brought to a stand by the arm F^2 coming against the catch-piece of the armature, which on the circuit being broken as just explained, falls back with that object: and now we have the "clear" spring in

contact with its stud ready for the receipt of the clear signal as shown by Fig. 84.

Our train now arrives at commutator *b*, which it operates in a similar manner, puting signal B at danger. It then passes over *a′*; the circuit is again completed, and the armature K is again attracted and now allows F^3 to pass. This done, the "clear" spring is freed from its metal stud, the "clear" circuit is again interrupted, the armature engages with F^3, and the signal stands at clear with its

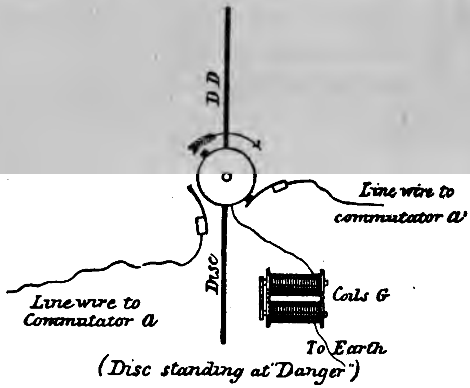


FIG. 84.

contact arrangements in circuit with commutator *a* ready for the next danger signal. When the train reaches *c*, the signal C is placed at danger, and when it passes over *b′*, that at B is restored to clear. Thus each train is protected by one, and at times by two, stop signals in its rear.

Of course, for single lines the system is applicable to blocking in front as well as in rear.

173. Moreover, it is capable of duplication, in which

case two signals take the place of one of those described. Let A B (Fig. 85) be a section. Duplicate signals are erected as shown at the commencement of each. The signal *aa* is dependable upon that at *a'*; and that at *bb* upon that *b'*. When *a* is at *danger*, *aa* stands at *clear*; when *a* is at *clear*, *aa* is at danger. Thus a train arrives at *a*, where it actuates the commutator and puts *a'* at danger. *a'* in taking its quarter revolution, from the clear position to that of danger, brings into play two springs fixed upon the signal shaft, which close the electric circuit with *aa*, and thus cause it to rotate from the *danger* position to that of *clear*. Should the commutator *a*, or the signal *a'* fail to act, *aa* remains at danger

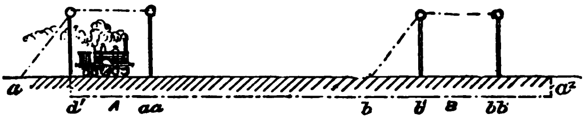


FIG. 85.

and warns the driver that such is the case. *a* is, when *on*, a *positive stop signal*; *aa*, when *on*, merely a *cautionary signal*.

On the arrival of the train at *b*, the signal b^1, if all in order, goes to danger, *bb* being set at clear; and on its passing a^2, a^1 is set to clear and *aa* to danger.

It will be evident that the signals may be actuated by a hand key from a signal-box, from the superintendent's office, or any other point; and that their repetition may be obtained automatically in any direction. The battery power can be kept at the stations and the current conveyed along the line by a wire provided *for that purpose*.

174. The system is necessarily worked by *momentary currents.* It is the invention of Mr. David Rousseau, of New York.

175. Dr. Whyte, of North View, Elgin, proposes, under a recent specification, to set the outdoor signals at danger mechanically; to set them at clear or caution by means of electricity; and further, by the latter agency, to warn the driver when such signals are at danger.

176. To this end each signal is provided with a special apparatus shown in Figs. 86 and 87, inclosed in a water-tight case to protect it from the weather. Fig. 86 shows

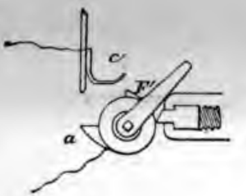


FIG. 86.

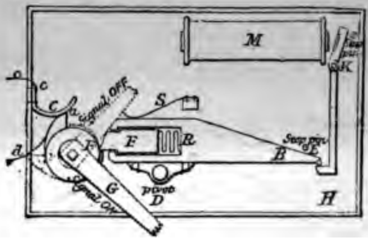


FIG. 87.

the arrangement when the arm is down, Fig. 87 that when it is raised. G is a crank lever in connection with a rod actuated by a lever laid alongside the metals, so that it may be actuated by the flange of the wheels of any passing train. As the semaphore arm is being raised the bolt F is pressed against the spring R by means of the graduated projection F^1. As soon as F^1 has passed the bolt it is again carried forward by the force of the spring R, when F^1 being unable to pass F, the signal is held at danger.

The bolt F is contained within a socket or frame B,

pivoted at D, and provided at one end with a spring S, and at the other with a check-bolt or stop-pin E; the tendency of S being, at such times as its influence is not overcome by the leverage of the arm when at danger, to keep the tail end of B pressing against E. M is an electro-magnet, K its armature, to which is attached a rod and catch-piece. When the arm is raised, B is tilted up at its tail end until F^1 has passed F, when it falls, under the influence of the arm, till it presses against the catch-piece, where it is held till a current is passed through M, when K being attracted, it escapes, and the leverage of the arm overcoming the influence of the spring, the fore end of B is raised sufficiently to allow F^1 to pass, and take up the position shown in Fig. 86. It will thus be seen that, contrary to the usual practice, the normal condition of the signal arm is *all clear*.

a is a graduated projection fixed upon the same arbor as is the signal arm, and moving with it. *c* is a spring so arranged that when the signal is at danger it shall be in contact with *a*.

177. On the engine or other portion of the train is placed a bell and a battery, together with three or more insulated metallic contacts, constructed and arranged that they shall form contact with corresponding metallic contact plates fixed on or above the roadway. Each of the ends of these contact pieces is formed either of a metallic brush or a piece of metal, hinged, so as to admit of a backward or forward movement. These are joined up electrically, as shown in Fig. 88—contact brushes 1 and 2 being connected together, 2 and 4 the same, with a battery in circuit, and 3 and 4 the same, with a bell as well as the battery in circuit. There is also placed on the engine a projection or stud 5, terminated by a small

friction wheel, the object of which is to depress the lever L, which is in connection with G (Fig. 87).

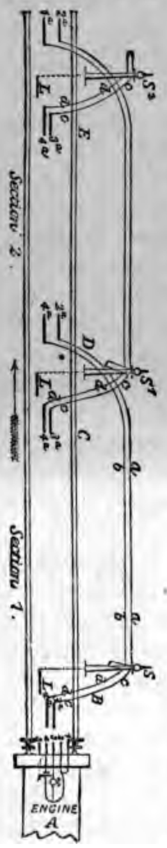


FIG. 88.

Along the line the block sections are marked by signals S, S′, S². To these are connected levers L, which actuate them as previously explained. Some two hundred yards in front of the signal are placed contact pieces or plates, 3^a 4^a, corresponding with the contact brushes 3 and 4 on the engine. To these are connected wires *c*, *d*, which are continued to the semaphore signal S, and there connected to the spring *c* and projection *a*. A short distance past the signals, plates 4^a and 2^a, corresponding as regards position with contact brushes 4 and 2 on the engine, are placed. At signal S′ there is a like arrangement, and so on for each block section.

178. Supposing the engine, as shown in Fig. 88, to advance in the direction indicated by the arrow, we shall have, on its arrival at signal S, contacts 3 and 4 in circuit with wires *c* and *d*, but these being disconnected at the signal post, the arm being at all clear, no current will flow from the battery, and the bell will not therefore be sounded. Arrived at L, 5 presses upon it and sets the signal at danger. The train now passes on till it comes to the plates in connection with signal S′. Here let it be assumed *that* the signal is at danger, and the wires *c*, *d*, are

therefore in circuit; a current will now flow through the bell to contact brush 3 of engine, to wire *d* to projection *a* (Fig. 87), spring *c*, wire *c*, plate 4^a, and contact brush 4 to negative pole of battery. The bell is thus set ringing, and the engine-driver is, by it, warned that the signal which he is approaching is at danger. His duty is then to pull up before he arrives at S′.

On S′ being lowered the train passes on, actuates the lever L, and again sets the signal at danger. Arrived at contact plates 4^a, 2^a, the contact brushes 4 and 2 on the engine, corresponding therewith, complete the battery circuit. A current passes from the engine to plate 2^a, wire *b*, electro-magnet M (Fig. 87), wire *a*, and plate 4^a to the zinc pole of the battery. On the passing of the current through M, K is attracted, and B being deprived of its support, no longer holds the projection F^1, which accordingly passes F, and the signal falls to the all clear position. The wires *a*, *b*, may be led into station-yards, termini, &c., and the current for the purpose of lowering the signal when desired sent by hand if preferred.

In the figure two wires are shown in connection with each pair of contact plates, but it is obvious that the "earth" may replace one of them, and the cost thus be confined to one wire instead of two. The approach of a train may be signalled to any given point by connecting such point by wires with contact plates, corresponding with brushes 2 and 4 of the engine.

179. The Royal Administration of Traffic on the State Railways of Sweden has recently decided on making experiments with an automatic electro-magnetic apparatus, the invention of Mr. H. Brunius, which has for its object the *prevention* of collisions, automatic registration

of movement of trains, communication with train when in motion, and automatic registration on the engine of the distance travelled.

To accomplish this two wires are required. These may be the ordinary telegraph wires, extended at the desired points to metal brushes supported by an overhead obstruction in such a manner that it shall make contact with a plate fixed for that purpose on the engine or other vehicle. Each wire and each brush is insulated, the one from the other, and the metal contact plates of the engine are so arranged that they shall make contact only with their respective wire, one wire with its extensions and brush being appropriated to one train, and the other to the following train.

The engine carries a bell and two indicators, one of which is required to record the distance travelled, and the other to indicate whether the train may "proceed" or whether it is to "stop." The former indicator thus has a step-by-step movement, each step being obtained by a current which is passed through the instrument on every occasion on which the train makes contact with the metal brush overhead. The "proceed" or "stop" indicator has but two movements—one to the right and one to the left—and thus gives at the same time the indication required, the one signal or movement being produced by a positive and the other by a negative current. The instruments are connected to "earth" by the engine and railway metals.

At either end of the section there is a duplicate clock-work arrangement insulated the one from the other, each propelling, under an electrical escapement, an indicating hand which traverses the same face-board, and which is provided with four flat circular metal rings. To each of these indicating hands is attached a tail piece which

traverses one of the metal rings. The positive pole of a battery is in circuit with two of these rings, and a negative pole with the other two. The centre of the dial is to earth. The two wires are connected to the hands which by their tail pieces are in contact with the rings, and thus a constant current flows along the line wire from the one station to the other. Each ring is divided into degrees or spaces, and each hand is moved one step forward each time its train makes contact with its extended wire at the overhead metal brush, or in other words, puts the line wire to "earth." So long as the current continues as originally arranged, the indicator on the engine obtains at each contact point the signal "proceed," the bell at the same time being sounded, and the "distance" indicator being moved forward a step, and this is the case so long as the trains remain apart the required distance. But now suppose the second or following train is travelling too quick for the safety of that in front of it, its contacts are more quickly made, and its clockwork hand is consequently advanced, in a corresponding manner, after that which is actuated by, and which indicates, the progress of the first train, until it comes in contact with, and rises upon the tail-piece attached to it. This produces a change in the battery current, so that if formerly the wire in connection with the second train was charged with a positive, it now acquires a negative current, and on the engine of this train making its next contact, a negative, instead of a positive current passes through its bell and two indicators. The "distance" in-indicator records another degree, but the remaining indicator is now brought over to "stop" instead of "proceed." The driver, seeing this, slackens speed, and brings his train to a stand *in contact with the next metal brush,* where, if the indicator again falls to "stop," he

has to remain until it is reversed, which reversal is of course obtained only on the preceding train having travelled a sufficient distance to move its clockwork hand away from that applying to the second train.

At each terminal station there is also a cylinder propelled by clockwork, and which has imparted to it a lateral as well as a revolving movement. This cylinder carries a sheet of paper or "train journal" divided into sections representing hours and minutes. In its neighbourhood are placed two electro-magnets, the armatures of which are provided with marking pens, so that when the armature of either is attracted a mark may be made upon the train journal. These armatures are attracted on their respective trains making contact with the metal brushes. Thus the form becomes a record of the progress of each train and at the moment is a confirmation, or otherwise, of the movement of the clockwork hands, whilst at other times it is available for reference.

If necessary the "stop" signal can be sent by hand to either train by reversing the battery current. The dial traversed by the clockwork hands is also provided with means by which, when the hands arrive at that point which indicates the neighbourhood of a station, the "stop" signal is sent, *in this instance*, as a warning that the train is approaching a station, and that it must slacken speed.

The three methods thus explained will serve to give an idea of the means by which it is proposed automatic signalling shall be carried on. In no case has sufficient experience of its capabilities been obtained to warrant any expression of its value. The employment of such means for working railway traffic involves deep and serious consideration. The expense attending the establishment and maintenance of the block-signalling system is un-

questionably very great. It is not the cost of the apparatus so much as the cost of the weekly wages. These considerations alone are sufficient to obtain, for any means which will enable a saving under this head to be effected, a favourable consideration. Automatic signalling would no doubt powerfully operate in this direction, and the only question to be solved is its reliability. With the present system of signalling there remains, on occasions of failure in any portion of the apparatus, a responsible officer, who, acting under prescribed rules and regulations, is able to take the necessary precautions for the protection of the traffic. With an automatic system devoid of line signals, failure means failure in full: there is no reserve. That failure will arise, whatever the agency employed—whether human, mechanical, or electrical—may reasonably be anticipated. Hence it is desirable that in the adoption of any automatic system there should be some form of reserve against the day of failure. On these grounds it is highly improbable any railway company will be found willing to adopt a system which does not embrace line signals.

Given a line wire with projections which may, by metallic brushes or springs, be brought into circuit with electrical apparatus arranged on an engine or other vehicle, there can be no difficulty in communicating with trains in motion so long as the conditions remain undisturbed; but in this much difficulty will be found, for even the traffic itself must occasion deviations in the course and the level of the metals; whilst it must be borne in mind that any system which may depend upon communication between train and train will admit of no omission in any one part, each train or engine must be complete in all its parts, and all must be in full, complete, and reliable working order. Considered as an adjunct—

as a further protection to the existing system of signalling —such an arrangement would probably be of some service.

180. To the efficiency of the present system of out-door signals is the degree of safety acquired by English railways mainly due. Any automatic system should be based upon the principles which govern that system.

1. **The normal condition of the signal should be danger,** *i.e.* any failure of the apparatus, or interruption of the wires, should result in producing this signal.

2. **The agency by which the signal is placed at "clear" should be, and remain active during the existence of such signal.**

3. **The apparatus employed should be perfectly free from atmospheric influences.**

4. The apparatus should be **simple, strong,** and **not easily deranged.**

5. It should be capable of **hand,** as well as **electrical manipulation.**

6. It should **conform to the existing system of electrical signals,** so as to work in co-operation with them at points where signal-boxes, and signal-men must, owing to local requirements, be retained.

There are no doubt many sections of railway where a system based on these principles would be a boon to the railway service, and whilst introducing a large economy, in no way jeopardise the traffic.

CHAPTER XV.

JUNCTION WORKING.

181. Junctions are a fruitful source of disaster. Void of electrical aid, it is to be feared they will largely continue so; but given a proper block system for the government of the traffic for a certain distance on either side of the junction, and it is not seen why—independent of such danger as there is attending all facing points—this should be. Properly worked, a junction, if not as safe as any straight road, should, at all events, be free from collisions.

182. The principle upon which all junctions should be worked is,

That each road about to be fouled by a coming train shall be regarded as one section, until such train is clear of the fouling point.

183. Let B, Fig. 89, be a junction of which ABC is the main line, and BD the branch. Now a down train from A, for C, will foul the *up branch road*, and therefore, before any such train is allowed to leave A, it is desirable any *up branch* train should be blocked back at D. In like manner as an up main, or an up branch train, must traverse the *same* road from B to A, it is clear there is

no advantage in allowing either one or the other to leave C or D until the other is free of the junction.

It will be observed that whereas a down main line train fouls the up branch road at B, it in no way interferes with the up main traffic; and in like manner that a down branch train in no way interferes with an up branch train. It is, therefore, desirable that the character of the train about to leave A for B—whether it be for C or for D—should be made known to B, and that a separate instrument for down branch trains should be

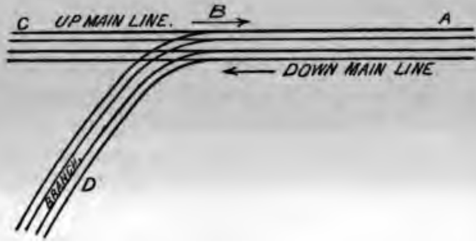


FIG. 89.

worked from B to A. Where the additional instrument is provided, all branch instruments should be kept at *danger*, and only the up and down main line instruments set at clear after the respective trains have passed out of the section. The additional instrument for down branch trains facilitates the traffic and affords greater security.

184. Following out the same principle with a triangular junction, Fig. 90, electric signals are necessary at A, B, C, and D, on the main line, and at E and F, on the branch. B, E, F we will take as E's main. Additional signals will therefore be required for down branch trains at A for the protection of junction B, at D for branch trains for the protection of junction C, and at F for branch trains,

proceeding towards C and D, for the protection of junction E. B and C will keep E constantly blocked for trains from that direction, removing the block only after having blocked the respective sections on either side from which approaching trains might foul the branch roads; and E will keep C constantly blocked for all trains from that direction, C being E's branch road.

185. It is highly desirable, to insure a due and faithful blocking of all the necessary roads, that the means by which the electrical block signals are worked from each of the junctions B, C, E, should interlock after the manner of the out-door signal locking frames. Thus: —

1. Before B can give the "clear" signal for a down

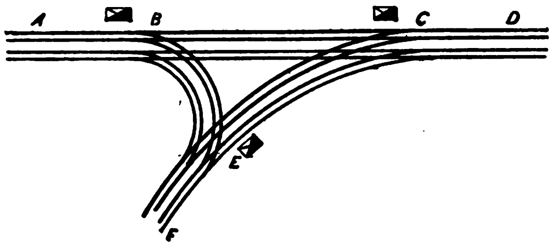


FIG 90.

branch train to A, it should be compulsory for him to block the up main road at C.

2. Before C can give the "clear" signal to E, for a train from that junction proceeding to D, it should be compulsory for him to block the up main at D, and the down main at B.

3. Before E can give the "clear" signal to F, for a train from F for C, it should be compulsory for him to block any *down train* from B.

Where the additional instrument for the respective branch traffic is not provided, the locking should apply to the ordinary signal instrument for the section affected,

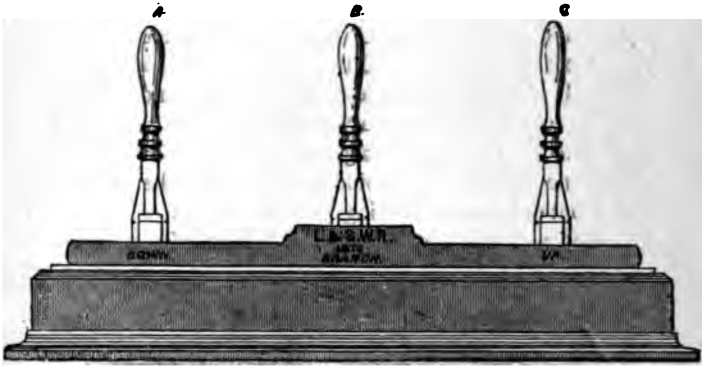


Fig. 91.

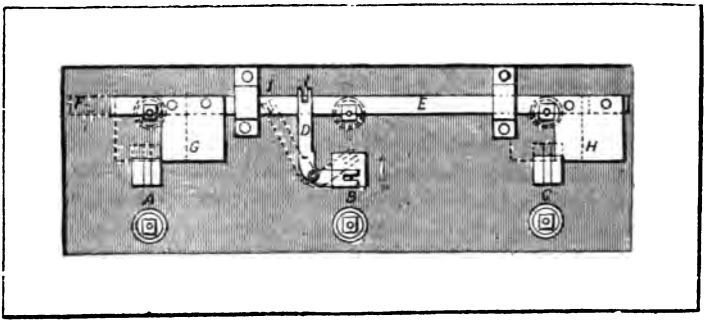


Fig. 92.

every approaching train being "warned" (§§ 157, 158) *in due course.*

The system of locking electric signals has, up to the present, been applied to but one form of instruments, viz., Preece's.

Fig. 91 represents, in front view, a junction-locking switch.

Fig. 92, the plan, as seen from underneath the base board.

Fig. 93, the end section.

In Fig. 92, the lower ends of the levers are shown at A, B, C.

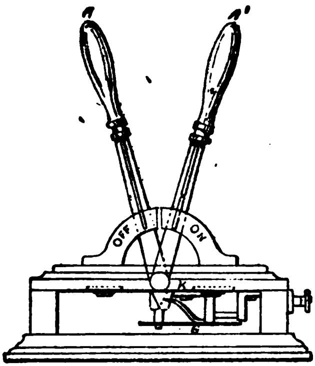


FIG. 93.

Lever B is fitted with a pin at its foot or lower end which pin works in the fork of an angle or elbow-piece D, which is also forked at its other extremity.

E is a sliding bar, free to move towards F, carrying with it two locking plates G, H. To this sliding bar is fixed a small pin I, working within the other forked end of the angle-piece D. It will thus be seen that the angle-piece D is governed by the switch lever B, and that *it controls* the sliding bar E; that to move the

N

sliding bar, we must move the lever B, and unless the sliding bar E is free to move, the lever B cannot be moved.

Levers A and C are slotted at their extremity, as shown at K in Fig. 93.

The movement of the several portions of the apparatus is shown by the dotted lines, and is further indicated by the arrows.

The position of the levers as shown by the plan, Fig. 92, is ON: that is, all the signals worked by them are at danger. Any one of them may be drawn over to OFF so as to place the signal worked by it at "clear."—Let us assume that lever A is drawn over to this position. It will then be in the position shown at A, Fig. 92, and its lower portion will stand in front of the locking plate G. If now we try to move lever B we cannot do so, because the locking plate G, banks hard upon the lower portion of A, and the sliding bar having but one movement, as indicated by the arrow, is thus immovable. But lever C is free and it may be drawn over to the OFF, or clear position. Now lever A controls the down main, and lever C the up main. Neither of these lines conflict, and hence it is not necessary the signals by which they are governed should interlock. But B governs the branch, and trains from that direction must foul both lines, the locking being arranged for a junction as shown in Fig. 89.

Now let levers A and C be placed at ON, and let B be brought over to OFF for a branch train. The sliding bar E, is now moved forward, and the locking plates, G and H, pass in front of, and within, the slot K, Fig. 93, of both levers. A and C are now immovable, and the signals which they work at the distant signal stations cannot be lowered.

The drawing represents a switch for working but three instruments—the up and down main, and the branch; but any number of levers may be made to lock in a similar way, and the locking may be diversified as required, by the removal or otherwise of the locking-plates in connection with the sliding-bars.

These switches are applicable to the single or three-wire systems of the inventor, the former, however, requiring any movement of the lever to be confirmed by a pressure of the signalling-key, or plunger. They are, moreover, applicable to the "double needle" block, Spagnoletti's, Tyer's, and Walker's systems.

186. Where the block system is not in existence, and where, from reasons of economy or otherwise, its introduction for the protection of junctions cannot be entertained, additional security may be obtained by adopting the following arrangement.

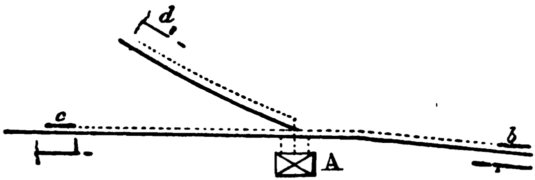


Fig. 94.

Let Fig. 94 represent a junction, of which A is the signal-box. Let the "stop" or junction signals, instead of being erected *at the junction points*, be placed some 300 yards away from it, as shown at *b*, *c*, and *d*. Trains will thus have a margin of 300 yards, ere they come foul of the points or cross-roads should the signal be against them, in which, should the driver be negligent or the metals slippery, the train may be brought to a stand and no *damage ensue.*

But occasions will arise, when, from fogs or other causes, the train may come to a stand at the stop-signal, and the signalman may not be able to see it, and may thus be unaware of its presence. If, however, a treadle, of such a length that two wheels of any coach, or the first and last wheel of any two vehicles shall rest upon it, be laid alongside the metal-rail for trains approaching the

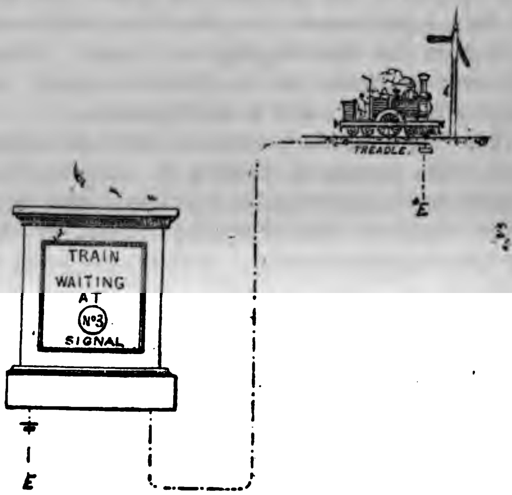


FIG. 95.

junction at *a point near* the signal-post, so as to be operated by the flange of every wheel; and this treadle be connected with an indicating instrument and a bell, fixed in the signal-box; and further, so arranged that on its depression, it shall put the line wire to "earth"; the signalman will have due notice, both by the ringing of the bell and the indication of the instrument, of the *arrival of* any train, and be able to take the necessary

steps in due course for its relief. Fig. 95 shows the electrical arrangement.

The distance at which the stop-signals are placed is, as regards this arrangement, immaterial, the object being to give as much margin as possible for careless driving, and to meet other circumstances under which a train may be so far past control, as to be brought to a stand before reaching the fouling, and consequently the danger point of the junction; but the distance at which these stop-signals are arranged must of course be, in a measure, controlled by the distance at which the "distant" signal is placed. The space between it and the "stop" signal should be sufficient to admit of a train being brought to a stand within it.

Siding Working.

187. All siding working at stations, or within view of the station signal-box, can, as a rule, be sufficiently provided for by the ordinary block-signals, that is by "obstructing" the stations on either side—without recourse to special appliances; but where the siding is situated at any distance from the sectional signal-box, it becomes necessary to make further provision for securing the safety of the traffic. In the mineral districts, junctions with local lines, sidings in connection with mines, manufactories, and collieries, become extremely numerous. They are, one and all, sources of danger unless necessary steps for regulating the traffic are taken.

Fig. 96 represents a section A B, with a mineral or accommodation siding C. Let it be assumed that a train arrives at A which has work to do at C. Now *safety* would be secured if on its passing A it were signalled to B in the ordinary way, so that A might be held blocked by

B until the train had arrived there; and if the down road were blocked by A (the train requiring to cross the down road at C) until the arrival of the train had been notified to A by B. But this would entail a complete stoppage of the traffic, for both up and down roads, during the entire time the train is in the section, including the time it is working at C. This is to be avoided by giving C communication with A and B. Such communication should consist of a bell between the siding-box and the station on either side, and two block instruments worked, the one from A,—governing trains proceeding from C to A,—and the other from B—governing trains proceeding

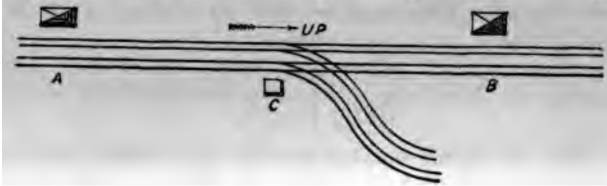


FIG. 96.

from C to B. The means by which these block-signals are worked should interlock as explained under the head of "Junction Working," so that A, when about to admit a train from C, may first be obliged to block B; and that B may be compelled to deal similarly with A, before allowing the siding train to foul the up road.

Let it be assumed that a train is about to leave A for B having work to do at C.

A man is detailed from A to accompany it and see to the crossing and signalling of it at C.

A signals it to B by a special "departure" signal, indicating "Up train left here having work to do at siding," and B blocks the up road at A in the usual manner.

Arrived at C, the detailed signalman does not permit the train to leave the up main metals, but, entering the signal-box, signals to A, "Train arrived and waiting to enter siding." A is aware that in order for it to reach the siding it must cross the down road. Before this is permitted, provided nothing has been signalled from B to A, he proceeds to block the down road at B by the usual "obstruction" (§§ 157, 158) signal, and when this has been acknowledged by B, and A is assured the electric signal for down trains is at danger at B, he places the siding block-signal worked by him at C at "all clear," which is the signal to the signalman waiting there that the train may be shunted across to the siding.

This "all clear" (§§ 157, 158) signal is acknowledged by C, but it will be observed that the block-signals at both A and B are still maintained at *danger*. The "all clear" signal received at C simply informs him that he may cross the train over, and he understands by it, that the up and down main roads are protected from any train advancing towards him.

The train is now, we will assume, crossed over, and when it is *clear of both roads, the up and the down*, the signal, "Train in siding, up and down main roads clear," is sent to A, and acknowledged. A now blocks the siding by placing his signal in connection with C at *danger*, and so long as it remains so *it is an indication to any train within the siding that it must not leave it or foul the main roads*.

A is now at liberty to clear the "obstruction" at B. The siding train has crossed the up and down roads, and he holds it within the siding by the electric danger signal worked by him at that point. Accordingly he does so, and again having signalled B, "Train in siding, clear up

road," B is at liberty to clear A from the block put on to protect the siding train when it passed A.

During the time the train is within the siding-signal the traffic between A and B may proceed in the usual manner.

But we now find the train at C has done its work, and is ready to proceed on towards B. The signalman therefore communicates to A, "Up-train waiting to come out of siding," which is acknowledged.

A has now again, provided no train has been signalled from B, to block the down road, and he accordingly "obstructs" (§§ 157, 158) B. He then signals the ordinary up-train "departure." This acknowledged, and assured that the down road is blocked at B, he is at liberty to give the *clear* signal to the siding. The train thereon crosses over to the up road and proceeds on its journey, the signalman detailed for that purpose communicating to A "Up-train left," when A again places his electric signal at C at danger, and relieves the "obstruction" at B. The signalman locks the *siding* points and the signal-box and returns to A.

A down train leaving B for C would be signalled to A in the ordinary way by a special bell code as "Down train left here, having work to do at siding." Arrived at C it would at once be shunted into the siding and the signal "Train in siding, down road clear," signalled to B. B would then signal to A "Train in siding, clear down road," and A would thereon be at liberty to do so.

Before the train can leave the siding, however, *it must obtain the clear signal from B*, in the same manner as has already been explained with reference to the up train.

It will be seen that with regard to down trains, as the *up line is not* fouled, no necessity exists for blocking it;

consequently the signalling for down trains proceeding to a siding such as that indicated in the figure is more simple than is that for up trains.

On lines where siding working is general, the system by which they are worked should be *universal.* Clear and concise instructions as to the method of signalling, the bell codes, and the circumstances under which trains may cross the roads or leave the siding, should be drawn out, printed, and posted in every siding and signal-box. All those using the sidings, whether guards, breaks-men, or engine-drivers, should be furnished with copies, so that they may become acquainted with the system of working and be careful to observe it. Whenever a man cannot be detailed from either signal-box for the purpose of conducting the signalling, and taking charge of the crossing operation at the siding, the signalman should understand from the guard that he is conversant with what is required to be done. The signalman at A is the responsible agent for all siding trains proceeding from A to B, and B for all similar trains proceeding in the opposite direction.

It may of course happen that a train requires to proceed from A to C, and then to return to A. It is clear that in a case of this kind, after the train has entered the siding and A has blocked B for it to come out again, it will be necessary for the down road to be retained blocked at B till the train has arrived back at A. B would understand the reason why the block was thus kept on longer than usual, from the absence of the departure signal.

Similarly a train from B to C returning again to B, would, before leaving the siding, require the up road blocked at A and the block kept on there until the train had returned to B.

For single lines, inasmuch as the road is always blocked in front as well as in the rear of any train, the method of signalling would be more simple from there being no other roads to cross, and consequently none to obstruct. On the arrival of the train within the siding, the station from which it started would be advised of it and would clear the road. The train would not leave the siding until the station in front, as also that in the rear, had been blocked, and the requisite permission to do so had been obtained.

DIVISION III.

MISCELLANEOUS APPLIANCES.

CHAPTER XVI.

SIGNAL REPEATERS.

188. Of the numerous applications of electricity to railway working, none are more worthy of attention than that by which the position of the signals which regulate the traffic is repeated back to the point from which they are worked.

If it is necessary to employ signals at all, it is equally necessary that they should work as they are intended—that is, that when they are, by the lever working them, placed at *danger*, they shall really stand at *danger;* and when they are "pulled off" they shall, in like manner, stand at the "clear," or "caution" position, according to the requirements of the locality, or the arrangement of the signal. Even with very careful attention on the part of those working them this cannot always be insured. The slightest change in the temperature, a passing cloud on a warm day, will lengthen or shorten the wire by which

the signal is worked. During night the wire will become contracted, and under the warmer atmosphere of the day it will again expand. These changes are constantly going on, in a greater or less degree, both night and day,

FIG. 97.

FIG. 98.

and to obtain a faithful action of the signal, the wire by which it is operated must be let out, or taken in, to meet these variations. If, in order that the signal *may not fail to go on*, the wire is allowed a superfluity of

slack, the arm cannot be lowered to its proper degree to represent the "all clear," or "caution" signal, and this induces carelessness and indifference with drivers. If the wire, on the other hand, is too tight the signal cannot assume the "danger" position, in which case the danger is enhanced.

So long as a signal is within a man's sight he may, in the majority of cases, be held responsible for its due action; but this is not possible at all times. Fogs and storms will arise, snow will cloud his view, and buildings, trees, or the construction of the line, place the signal out of sight. Even when it is within his view other duties may form an excuse for not keeping so careful an eye on it as is to be desired; but if an instrument is placed before him which tells him whether the signal is *on* or *not*, or whether it is *on* or *off*, and it is a part of his duty when working the signal, to learn by this instrument whether the signal *has responded to his action*, the responsibility becomes too great to be ignored.

At night time, and during foggy weather, all depends upon the light within the signal-lamp and the due action of the "spectacles." If the light goes out there is no signal. If the spectacles fail the signal is false.

Electricity affords a means for ascertaining the position of the arm to a fraction of an inch; and by its means we may also assure ourselves of the due action of the "spectacles," and of the existence, or non-existence, of the light.

Figs. 97 and 98 are outside representations of an arm, and Fig. 99 is a representation of a combined arm and light repeater.

These instruments may be made of any form. Those represented in the figures are known as Preece's and are made of various shapes, sometimes as represented, at

others in a small rectangular case, and again in a circular case, according to the position they are required to

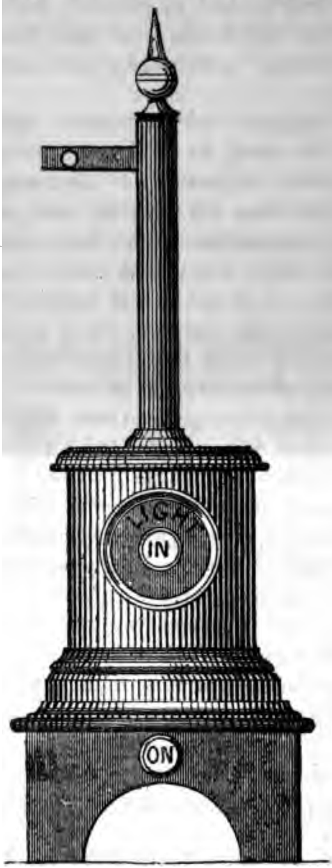


FIG. 99.

occupy and the taste of the telegraph engineer Mr.

W. H. Preece was the first to employ them, about the year 1861. Mr. A. Warwick, of the Midland railway, shortly afterwards introduced them on that line, and they are now very generally employed on all important railways. The form of indicator (Fig. 100) adopted by Mr. Warwick is that of a needle, which, for the arm, is made to point to "signal on" or "signal off" as the case may be; whilst that referring to the light is directed in a similar manner to "light in" or "light out."

189. Each indicator—that for the arm or that for the light—requires an insulated wire between the signal-post and the instrument.

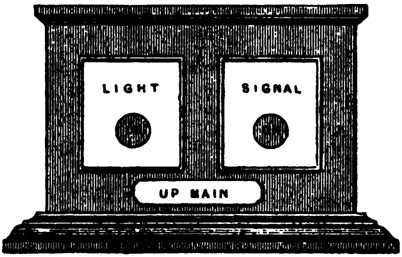


FIG. 100.

To one end of the coils from which the arm is worked is attached a battery A (Fig. 101), the other pole of which is to the earth, and to the other end of the coils is connected the line wire B, which is continued to the signal-post, and there attached to the spring C of the contact maker (Fig. 102) fixed in close proximity to the signal arm. To the back of this arm is a metal stud D, the object of which is, when the arm is at danger, to press against the spring C and so bring it into contact with the point E, which is in connection with the earth.

Now, when the arm is raised to danger, it will bring D in contact with C, which will be pressed against E, thereby completing the electrical circuit between earth at the signal-box, and earth at the signal-post. The

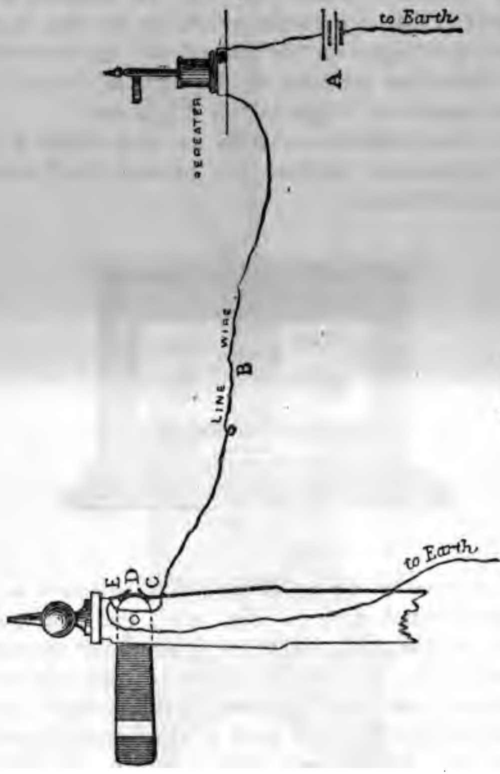


FIG. 101.

battery current will then flow from A, through the coils *of the instrument*, raising the arm to danger, along the *line wire B, to* C, and thence to E and the "earth."

On the signal arm being in the least depressed, C will cease to press against E, and the connection between the line wire and the earth being thus interrupted, the current from A will cease to flow. The coils of the instrument,

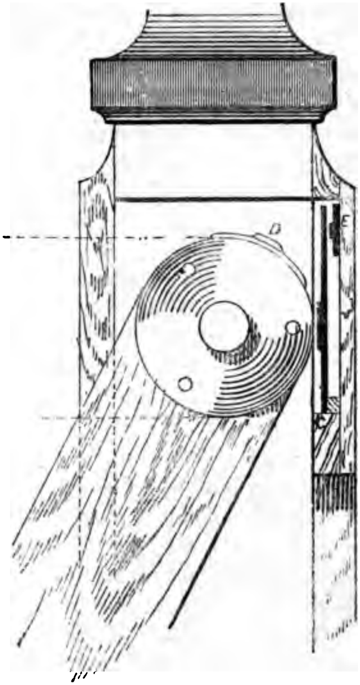


FIG. 102.

now no longer excited, will exercise no influence over the armature by which the arm of the repeater is actuated, and the arm will fall to its normal position, indicating that the *signal* arm is ***not on.***

190. Fig. 103 represents an arrangement for obtaining a record of the condition of the signal arm at three different positions, viz., when it is at *danger;* when it is at *all clear*, or *caution;* and when it is in a position *between* either of these signals. E F is the electro-magnet, *n n'* two pieces of magnetized steel, centred at *a*, to which is connected, eccentrically, a wire rod *b*, actuating the arm. When a positive current is sent through the coils, *n* will be attracted and *n'* repelled; the arm will thus be raised. When a negative current is employed, *n'* will be attracted and *n* repelled; the arm will then be depressed to its lowest position, either "all clear" or "caution." In order to retain the arm in either of these positions there must be a constant current of the character required (positive or negative) flowing through the coils. As soon as this ceases to be the case the magnets, *n n'*, assume a position midway between that produced by the passage of the two opposite currents, which produces a corresponding position of the arm.

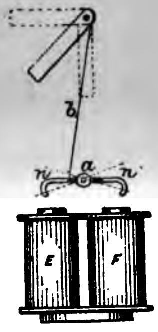


FIG. 103.

191. On the Great Western railway Mr. Spagnoletti uses a form of instrument similar to that employed by him for his block-signals, except that the two signals, that for the arm and that for the light, are arranged one above the other. On the dial-plate or face of the instrument is painted the word "Signal," immediately over the aperture which is filled by the shield (Fig. 60) carrying the words ON and OFF; either one of which should be exhibited at the aperture according to the position of the arm or the signal which it repeats; when this is not the

case the shield assumes a neutral position, showing a portion only of each word.

192. Repeaters, giving more than two indications, require additional wires, or that the batteries should be kept at the signal-post. The employment of a reversing key at the arm would dispense with one battery; but inasmuch as this would subject the battery employed to constant use, any advantage attending such an arrangement is questionable.

193. An ingenious method has been proposed by Mr. W. H. Preece, by which this difficulty may be overcome. He suggests a duplex arrangement such as is shown in Fig. 104.

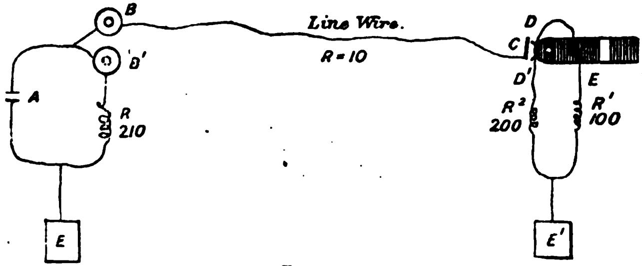


FIG 104.

A is the battery, B B′ the coils of the repeater, R a small resistance measuring 210 ohms, C the spring in connection with the signal-post, D a stud on the arm, making contact with the spring only when the arm is raised to the danger position, D′ another stud, also on the arm, making contact when the arm is in the position representing "caution." In connection with D is a small resistance coil R′ of 100 ohms, and in connection with D′ is another resistance coil R² of 200 ohms, both of which are joined to "earth."

Now when the signal-arm is raised so as to place C in contact with D, the battery current will have two roads open to it—one *viâ* B, D, and R′ to earth at the signal-post; the other *viâ* B′ and R to earth at the signal-box; but as the resistance of the one circuit, or road, is double that of the other, the influence of the current will be twice as great on the one coil as it will on the other. And if the coils of the instrument are connected up in such a manner that any current passed through them shall produce magnetism of an opposite character in the cores, it will be evident that when the two roads are equal, and consequently a current of equal force passes through each coil, no magnetism whatever will be engendered, for the reason that that produced by the current flowing in one direction, is opposed to that produced by the current flowing in the opposite direction. But where the roads are not equal, then the shortest circuit, or that which presents the least resistance[1] to the passage of the current, will produce a certain preponderancy of magnetism, the polarity of which will be according to the direction of the current.

So in the case before us, the road B D R′ presents the shortest route, and if an instrument constructed for duplex working is employed we shall have the armature attracted by one coil and repelled by the other; producing the "danger" signal.

If the signal-arm is lowered to the "caution" position, we shall have the stud D′ in circuit with the spring C,

[1] *Resistance* implies that quality of a conductor in virtue of which it prevents more than a certain amount of work being done in a given time by a given electro-motive force. Thus the space between any two points offers a certain obstruction to the passage of the current, no matter of what the space be composed, whether air, water, metal, or other material. The obstruction offered to the current is termed *resistance.*

and now the two roads will be equal; the battery current will divide on entering the coils. One portion will pass through coils B, line wire ($R = 10$), D′, $R^2 = 200$, to earth at the signal-post. The other portion will take the artificial route by way of coils B′, $R = 210$, and earth at the signal-box. In each case the resistance or electrical measurement of the circuits will be the coils of the instrument + $R = 210$, and the resistance of the coils being equal the current will be equally divided, and its influence equal. No magnetism will therefore be produced, and the armature will assume a normal position, producing the "caution" signal.

But now if the signal-arm is lowered to the "all clear" position, the line wire will be entirely disconnected at C, and thus there will be left but one road open for the current, viz., that *viâ* B′ and R 210. In this case the armature will be actuated in an opposite direction to that first explained, and the arm of the repeater will be lowered to the "all clear" position.

194. Another suggestion which has been made is that the various positions of the distant signal-arm shall bring into circuit a varying resistance, so that by the increased resistance thus thrown into the circuit the influence of the current over the armature of the instrument may be reduced until it reaches the zero point, which would, of course, be either the "all clear" or "danger" indication. It is scarcely a desirable arrangement; inasmuch as, for reasons which will be discussed hereafter, it is desirable the normal indication of a repeater instrument should be "all clear;" the opposite signal ("danger") would, under this arrangement, be dependent upon the force of the current. If this were from any cause reduced, the arm of the repeater would not rise to danger; the signalman would soon ascertain that this was from no fault of his

signal, and would, in the course of time, become indifferent to it, possibly, at a moment when his signal really did fail. In fact the indications, apart from the normal or zero position of the instrument, would not be those of the distant signal, but of the strength of the battery in relation to the resistance of the circuit.

195. The arm or the disc is the signal which governs the engine-driver by day, the light that which governs him by night. The methods by which a faithful record of the condition of the arm may be obtained have been fully dealt with, and thus the question of the day-signal may be said to have been disposed of.

The night-signal is dependent first on the light, and secondly on the "spectacles" or the colour of the light, viz., whether red or white, red or green, or whatever it may be.

The movement of the spectacles is, or should be, synchronous with that of the arm. They are usually attached to the rod which works the arm, and thus the motion which produces the danger-signal in the arm brings the red spectacle in front of the lamp, thereby showing a red light.

Hitherto but little, if any, attempt has been made to obtain a repetition of the movement of the spectacle. The need for such will be self-evident. The same causes which operate against a faithful action of the arm also operate against the spectacles, and it is equally as necessary that the night danger-signal should be as unmistakably a clearly defined red light, without any white showing, as that the day-signal should be a well defined horizontal position of the arm. Although improbable, there is yet the possibility of the framework of the spectacles becoming loose on the rod.

All that is necessary to obtain this record, is to make

the connection between the arm and the earth through the spectacles, so that when they occupy the danger position the circuit shall be complete, but when this position is in the least departed from the circuit shall be

FIG. 105.

broken as represented in Fig. 105. Thus the movement of the arm and of the spectacles may, where the record required is that of the danger-signal only, be obtained by

one and the same wire. Where the various motions of the arm—danger, caution, and clear—are required, the connections at the spectacles must conform to those of the arm, the due action of the one being consequent upon that of the other.

196. **The record of the light** is obtained by a distinct wire. The action of the indicator depends upon the action of the apparatus placed within the lamp, the

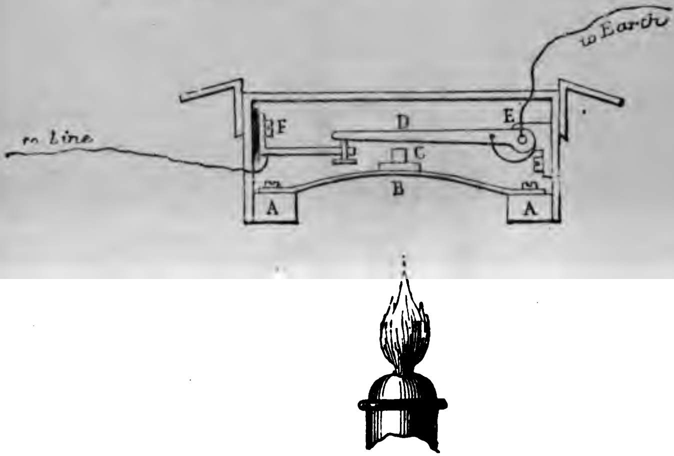


FIG. 106.

arrangement of which should be such that it will be under the influence of the heat derived from the flame furnishing the light.

Regarding Fig. 106 as a central cross-section of that portion of the apparatus employed within the lamp, A A is a circular iron frame, preferably made of cast-iron, as being less susceptible of expansion from heat. B is a *disc of copper* to fit A, beaten somewhat concave, and

firmly fixed at its circumference to the frame A. At its centre, on the reverse side to the frame, is a stud or pin C. D is an uninsulated lever centred at E, having imparted to it a tendency to move downwards by the spring at E. F is an insulated cock, with adjusting screw, the object of which is to regulate the space between C and D, as may be required, and to complete the electric circuit when D is in contact with it. To the insulated cock F the line-wire is joined, and the framework of the instrument is carried to earth. The diameter of the iron frame A may be about three inches, and the contact portion should be covered in to protect it from dirt. The whole may be very conveniently fitted within the top of a signal-lamp without interfering with the light or draught.

The internal arrangement of the "light" recording instrument consists of a pair of coils, to the armature of which is attached a wire rod with a bell-hammer at its extremity. Beneath the instrument is a bell-dome, so fixed that any movement of the armature shall cause it to be struck by the hammer. The line-wire is connected with the coils through a make-and-break arrangement, by which means, so long as a current flows through the wire, a continuous ringing of the bell is kept up. Between the poles of the electro-magnet is a permanent magnet carrying a shield with the words OUT and IN, so adjusted that it shall, under the influence of gravity, exhibit at an aperture in the face of the instrument the word IN, whilst the influence of the electric current shall, by reversing the position of the indicator, present the word OUT. Now if one pole of the battery be connected, through the make-and-break arrangement, to one end of the coil applying to the "light" instrument, and its other pole be put to earth, and the remaining end of the coil be connected

to the line-wire, we shall have, in the normal state of affairs—that is when there is no light in the lamp, —a continuous current flowing through the coils of the instrument along the line-wire to the adjusting screw F, and through the lever D, to earth at the signal-lamp. But now let a light be applied to the lamp. The heat will speedily expand the metal disc B, which in expanding will carry upwards the pin C, press it against the lever D, and finally carry away the latter from F. The line is then interrupted, and no current can pass: the bell ceases ringing, and the indicator being no longer under the influence of the current falls back to $\left\{\begin{matrix}\text{LIGHT}\\ \text{IN}\end{matrix}\right\}$, and there remains so long as the influence of the heat

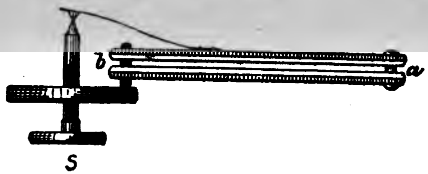


FIG. 107.

upon B keeps up its expansion. Thus, when the light is burning the indicator shows "light in," and the bell is quiet; when the light grows dim, or goes out, the electric circuit is again completed, the indicator records "light out," and the bell continues to ring until the light is restored. In front of the instrument is fixed a switch, for the purpose of putting the light arrangement in circuit at pleasure, as it is manifestly only required when the lamp is in use.

The "light" contact arrangement varies equally as much as does the form of indicator employed. Two *dissimilar* pieces of metal, as steel and brass, are at times

employed: or this may be duplicated as shown in Figs. 107, 107*a*.

The steel of the top-plate is on the upper side, the brass at the bottom. The lower plate has the steel underneath; they are both riveted together, at one end *a*, and at the other end *b*, *one* plate is connected with the side of the lamp. S is a contact-screw insulated from the rest of the apparatus.

Under the influence of heat the plates curve in opposite directions, and the lower composite plate also tips the top one upwards, adding this motion to that obtained by the curvature by heat, and the two plates assume something like the position shown by Fig. 107*a*.

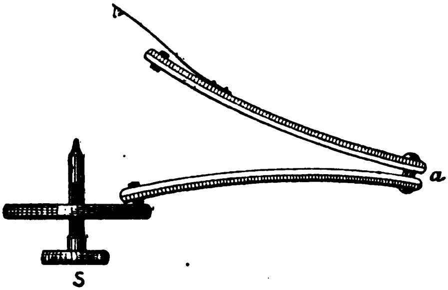


FIG. 107*a*.

Thus without the assistance of any multiplying lever or other device of the kind a very wide motion is obtained direct from the source, so affording great nicety of adjustment by the insulated contact-screw, as well as a good rubbing-contact.

Another simple method is that shown in Fig. 108.

A is a piece of ¾-inch brass tubing rigidly fixed at one end, B, to the iron frame G, provided with a brass pin at F, its other extremity, which is free to move within a slot.

D, cut in the frame. At S a small lever, SF, is centred at S, having its end, F, normally held in contact with the insulated cock C. The line-wire is connected to C, and the earth to the iron frame G.

On subjecting A to the influence of the heat of a flame of gas, or oil, or that of a candle, the tube will expand, and being immovable at B, this expansion will be in the direction of D. It will consequently press against that end of the lever SF, carry it away at F from the contact-stud C, and so break the electrical circuit.

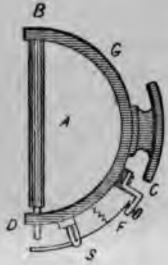


FIG. 108.

A spiral of metal has also been employed, but it will be evident that the means by which the interruption of the circuit may be obtained, under the influence of the heat of the flame, are almost unlimited. The main points to be observed are, **a ready expansion and quick return to the normal position, strength and durability, cleanliness of the contact portions, and compactness.**

It is very necessary the arrangement of the expansion-piece should be such as to insure its ready return, on the withdrawal of the heat under which it is made to expand, to its normal position, so as to insure contact between the line and the earth-wire. At the same time it should be strong and not too delicate, capable of good adjustment, and easily accessible to the lineman.

To adjust it for a ready intimation of any failure of the light, *the expansion-piece should be exposed to the heat of the flame for some twenty minutes, and then the adjusting*

screws in connection with the line-wire set so as to just break circuit.

The main points to be considered in connection with the application of electric-repeaters are dealt with in the following remarks :—

197. *To what Signals should Repeaters be applied?*—It is scarcely necessary to say their chief application must be in connection with the distant signal. Distant signals are the farthest removed from the signalman, and are thus more apt to be obscured from his view in fogs and bad weather than those nearer home. At the same time it is an open question whether starting-signals and home-signals, and especially junction-signals erected over the signal-box, should not in a similar manner be repeated back to the signal-lever. It is no doubt a safe principle to consider the working of a railway under its most adverse circumstances, and to provide for it accordingly. Perhaps a dense fog is one of the worst conditions under which railway traffic can be worked. At such moments the importance of the due action of every signal cannot be over-estimated.

198. *The nature of the Indication.*—Considerable diversity of opinion exists as to the nature of the indication necessary to be recorded: whether the repeater should simply show when the signal is at "danger"; whether it should show when it is "on" and when it is "off"; or whether it should record the three positions, "danger," "caution," and "clear," or even go beyond this, and show the intermediate positions.

Now here let us consider what is the point of danger. Clearly the point of danger is that when a signal which is intended to be at danger, and which has, so far as the means of working it is concerned, been set at danger, *does not stand at danger.* It is then the man working

requires to be told the signal is *not on*. If a signal does not stand *off* when it is supposed to have been pulled off, no positive danger will arise. An approaching train would draw on to within sight of the home-signal, and seeing this at "all clear" would proceed, the driver probably indicating to the signalman as he passed that his distant signal was not "off." With such indications and with the whistle of each succeeding train, the signalman would speedily see to the adjustment of the wire. Repeaters, to a considerable number, are worked on this principle; but one wire is required, and the battery power is only in operation during such time as the signal itself stands at *danger*.

To show when the signal is ON and OFF, or to show when it is at "danger," "caution," and "clear," requires two wires; an application of the duplex mode of working and a modified arrangement of the instrument; or placing the batteries at the signal-post, an objectionable course, as they would certainly freeze during very cold weather, and thus render the electrical-signal inoperative.

199. *The Point of Connection with the Signal.*—This is an important question. It is the arm which constitutes the signal by day and the "spectacles" by night. To these parts then the connection should be made. Hitherto no connection whatever has been attempted with the "spectacles," the attachment being made either to the arm, or to some part of the rod, or the lever working the rod in connection with the arm. A moment's reflection will show how desirable it is that the connection should be with both the arm and the spectacles in such a manner that the action of the one shall be made depen-[illegible]nt upon the action of the other. This may be done [illegible]means of the same wire, and with merely the additional [illegible]ense of another pair of springs.

It may be argued that there can be no reason to doubt the due action of the arm if the lever has *its* due action, but there *is* the chance, although perhaps a remote one, of a bolt giving way, or the arm becoming loose; and it is desirable to provide against such chances happening at inopportune moments. There are signals which, from their height and construction, it would be difficult to so fit, but these are the very signals which *should be so fitted*, because it may be fairly assumed they are, from those very causes, less likely to meet with that careful inspection from the mechanical branch of the service so necessary to keep them in proper repair, and so avoid failure.

Disc signals should in a like manner, where possible, be fitted at the iron shaft to which the disc is fitted, and the electrical connection with these should be made, as with the semaphore, through the fittings applied to the shaft carrying the lamp for the night signal.

200. *The Form of Instrument and its Indication.*—There is probably no great choice between the forms mentioned, for assuming every signalman is sufficiently educated to read the words inscribed he can make a mistake with difficulty; still there may be an advantage in employing that form of instrument which accords most with the signal, and requires merely a knowledge of the form and action of the signal to decipher a *danger* from a *clear* or *caution* signal.

201. *Electrical Construction.*—The instrument should be so constructed that it should be *undemagnetizable, and its signals unreversible from atmospheric causes.* Its normal condition should be that which affords the "all clear," or "caution" signal, where the signal repeated can only be lowered to that position. Its "danger" signal should be that produced by the action of the electric current.

The reasons for this will be self-evident. If the signal

be not unreversible from atmospheric causes there will be the possibility of the indication being opposite to that intended. If it is not undemagnetizable, the signal will be wanting in intensity or completeness. If its normal condition were that of *danger* instead of *all clear*, any defect in the apparatus, or the wire, would show the signal to be at danger when it might not be in that position. Constructed upon this principle, gravity may be employed to produce the *all clear* signal, and the action of the current the *danger* signal.

202. *Signalmen* should be instructed, wherever a repeater is in use, *not to suppose, if it should not act in concert with the signal-lever, that the repeater is wrong, but on the reverse, to conclude that it is his signal which is wrong, and to take steps at once to assure himself of the contrary.*

203. The electric repeater is a good disciplinarian. It introduces a *regularity* in the character of the signals which is otherwise frequently absent. Let the early traveller notice the signals at the different stations as he passes along. Here he will see one standing well out, fully at danger; there another with an inclination towards caution, ashamed, as it were, to look the driver in the face. The manner in which a signal is made to deliver its message is a very good indication of the character of the man who works it. If it comes well to danger, and again falls well to clear or caution, it is well attended, and shows a desire on the part of the man who works it to carry out his duties well and faithfully. A slovenly man is too lazy to attend to the adjustment of his wire until he is obliged to do so; but let him have before him a monitor which says to him, "Your signal is not on," when he has contented himself with throwing his lever over to danger, and his responsibility is too great for him *to disregard* it.

CHAPTER XVII.

INTERLOCKING SIGNAL LEVERS.

ELECTRICAL engineers would appear to have given but little attention to the application of electricity to locking signal levers, for very little has been done in this direction.

204. In 1870 the method illustrated by Figs. 109 & 110 was introduced, and is still employed on the London and South Western Railway, in conjunction with Preece's three-wire system of block-signals (§ 110), which it will be remembered is so arranged that gravity produces the *danger*, and a constant current the *all clear* signal.

Fig. 109 is a sectional side view, and Fig. 110 an end representation of the arrangement, which consists of a pair of coils E, an armature pivoted at F, to which is fixed a bar B, having suspended from its extreme end a small rod A, to which is attached a block of steel or other hard metal, C. The bar B is provided with a sliding weight G, the object of which is to counteract the weight of the metal block C, and so produce as nearly as possible a state of equilibrium in the rocking lever B, the preponderancy being such as to merely withdraw the armature from the cores of the coils, and so allow the metal block C to drop within the slot H of

P

the iron frame to which the instrument is fixed, and which is placed immediately in front of the lever to be locked. A slot is cut in the iron frame for the

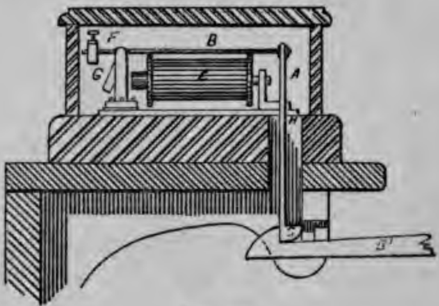


FIG. 109.

accommodation of the rod A and metal block C, so that, when the condition is that shown in the figure, and an attempt is made to draw over the signal-lever, the

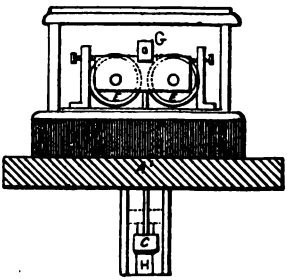


FIG. 110.

locking bar B′ may engage with C, which, banking against the shoulder pieces seen in Fig. 110, will prevent B′ *being fur*ther withdrawn.

Now, on a current being passed through the coils E, the armature will be attracted, G will be depressed and C raised sufficient to admit of the locking-bar B′, attached to the signal lever, being withdrawn from the slot H in the iron framework through which it has to pass whenever the lever is placed in the danger position.

The instrument may be worked in circuit with the semaphore block signal, or by relay in connection with it.

It may be employed for locking either signal or point levers, in connection with the block-signals, or independent of them, for shunting and yard purposes.

205. A somewhat similar arrangement is also employed by Messrs. Tyer and Norman. It is represented in Fig. 111. A is the signal lever, B a rod connecting it with another lever or bar centred at C, provided with a catchpiece D, which is supplied with a tripping projection so weighted that in its normal condition it shall engage with the lever E working upon an independent centre G. To the lever E is attached the wire in connection with the signal, and when D is at liberty to engage with E, the lever A, on being drawn over to the *off* position, will raise it, draw in the wire, and so lower the signal.

H is an electro-magnet in circuit, by relay or otherwise, with the distant signal box. K is its armature centred at L. When the lever A is drawn over to the *off* position K is lifted up by the lever centred at C to the vertical position, and, if a current is flowing through H, it will be held there, but if no current is flowing it will fall back and, resting upon the tripping projection of D, prevent it from engaging with lever E, and consequently will not admit of the wire being drawn in and the signal lowered to the "clear" or "caution" position.

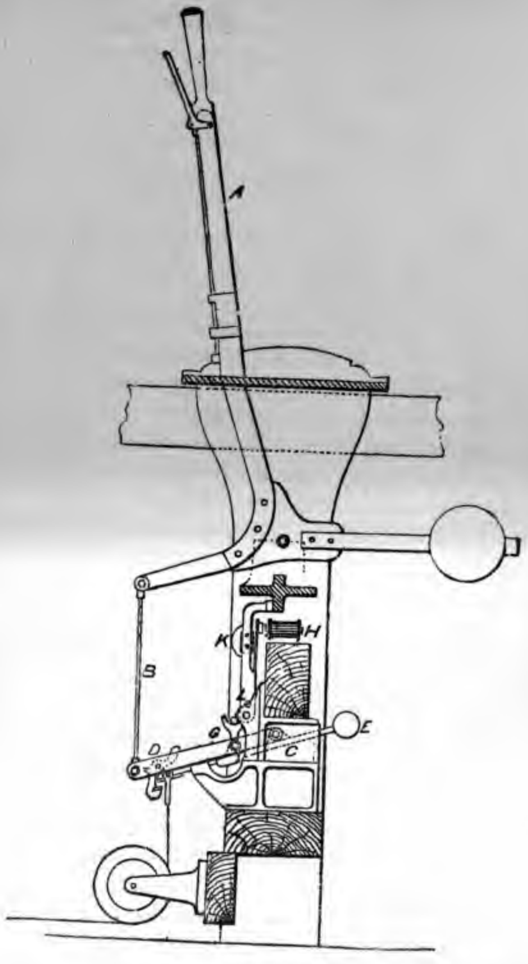


FIG. III.

CHAPTER XVIII.

BELLS.

206. NUMEROUS kinds of bells have from time to time been employed on railways and for railway purposes. The earliest was *electro-mechanical* in arrangement. The bell was sounded by a set of beaters which were revolved by means of a train of wheels under the influence of a spring, the mechanism being set in motion by the disengagement of the armature of an electro-magnet. So long as the armature was held down by the current and the mechanism was under the influence of the spring, the bell would continue to ring, and thus it emitted a series of rings somewhat similar to a mechanical house-bell, but of better tone and greater uniformity. On the current releasing the armature, the mechanism brought into position a trigger or catch-piece, with which the armature engaged, when the motion ceased. The action of the bell was dependent, in the first place, on the spring being kept wound up; secondly, on the adjustment of the trigger or armature; and thirdly, on the strength of the current. Such bells were unreliable for obtaining any specified number of beats, as not on all occasions did the trigger and armature engage; in which case the wheel carrying the beaters would make another

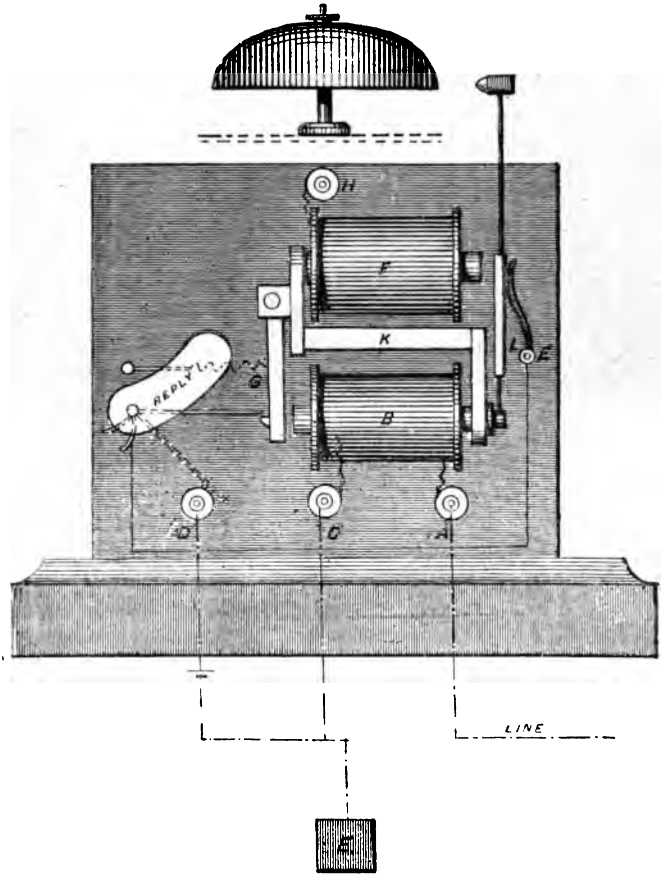


FIG. 112.

revolution, and an additional number of beats, corresponding to the number of beaters on the wheel, would be sounded. As alarums for calling attention they were no doubt serviceable, but as signalling instruments nothing could be more unsuitable.

207. The Ragon bell is a bell somewhat similar in character as regards its delivery, the ringing being continuous until interrupted by the action of the attendant. It has however, this advantage over the electro-mechanical bell: it requires no winding up.

Its arrangement may be understood from Fig. 112. The instrument may be fitted with a key or not.

The current enters at terminal A and passes through the lower coil B, which is insulated from the framework. The armature G is attracted, and discharges the rod seen in connection with the indicator carrying the word "Reply," which falls upon, and makes circuit with, the stud D. The current from the local battery now flows by way of D to the framework of the instrument, and on to the spring E. Here it passes into the armature L, and thence by the cranked bar K to the coil F, which it leaves at H, and passes to earth.

When the lever which rests upon G is discharged, the disc—on which may be printed any instruction thought necessary—drops so as to become visible at an aperture provided for it in the outer case of the instrument. It is replaced by pressing down a stud arranged for that purpose on the top, or at the side of the instrument cover.

We will now suppose a current sent from the distant station. It passes through the coil B direct to earth. But immediately the armature G is attracted so as to discharge the indicator, the home battery comes into action, the armature is attracted and leaves the spring

E, and the circuit is then broken. The armature then falls back into its position of rest. L again comes into contact with E, by which the circuit is once more restored, when the armature is attracted as before, to fall back again as soon as the bell has been struck by the hammer attached to L. In this way a continuous ringing is kept up so long as the indicator remains visible at the aperture in the face of the instrument.

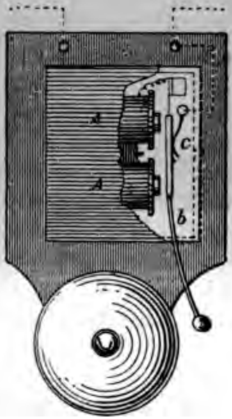


FIG. 113.

Such bells are very serviceable for obtaining the attention of those whose duties are of a mixed character.

208. The **trembling bell** is of a more simple construction, and for many purposes equally, if not even more serviceable than the Ragon bell. Its construction is shown in Fig. 113.

A A is a pair of coils, *b* the armature, and *c* the make-and-break spring pressing against the latter. On a current *passing through* the coils *b* is attracted and the bell is

sounded; but no sooner is this effected than *b* leaves *c*, and the circuit being broken, *b* again returns to its contact with *c*, and the movement is repeated. This continues so long as the current flows from the distant end. A series of rings may thus be sent, indicating various signals, such as—

2 series of rings—stopping train.
3 „ „ non-stopping train.

The spring *c* should be so adjusted that the armature *b* shall only break contact with it when striking the bell.

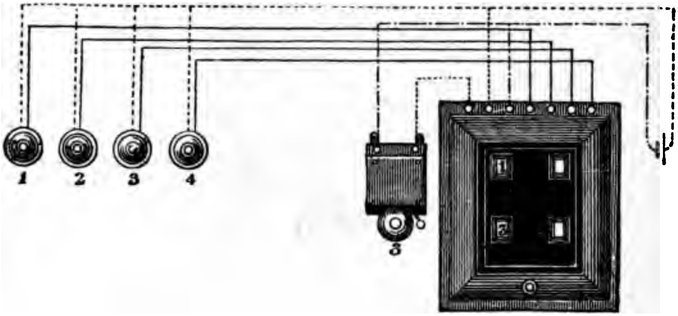


FIG. 114.

It is very necessary that the point of contact between them should be kept clean.

When made large, and the coils wound with insulated copper-wire of No. 18 B.W.G., they are very useful as platform-bells.

209. When of the smaller type they are chiefly serviceable for **office communication**; Fig. 114 shows the method of joining them up for this purpose.

1, 2, 3, 4 are separate offices, each provided with a small commutator termed a *button* (Fig. 115), which is fitted with two springs, *a* and *b*, the latter of which stands

out from the former, and is brought into contact with it by pressing the small ivory knob *c*. So long as *c* is pressed therefore *a* is in contact with *b*.

An indicator, a bell, and a battery are placed in the attendant's office, the wires are connected as shown in the figure, and from each of those leading from the bell and the battery, *leads* are made to the buttons 1, 2, 3, 4. The contact springs *a*, *b* (Fig. 115), being normally asunder, the circuit only becomes closed when either of the knobs, *c*, is pressed, when the bell is rung, and the indicator distinguishing the room requiring attention is brought up to view. Without the aid of this indicator

FIG. 115.

each office must adopt a different series of rings to indicate from which the call is made; thus 1 would press the button once, and one series of rings would be produced; 2 would press his button twice—that is, once, then give a slight pause, and then press again—and two series of rings would result.

210. Such an arrangement, minus the indicator, is not convenient for a number of offices, or where the attendant is not always within hearing of the bell. It is then desirable to supplement the bell by an *indicator*, the interior construction of which is shown in Fig. 116. The figure *represents* but four indices; but such an instrument may

be made to provide for any number. Each indicator is actuated by its own small electro-magnet, shown at index number one by the letters *c c'*. The indices are formed of thin cardboard or mica, upon which the numbers or names of the rooms or offices are inscribed. They are fixed upon a small permanent magnet, pivoted

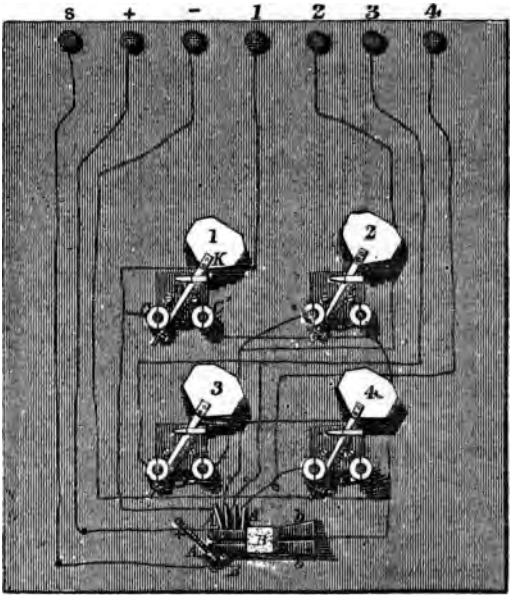


FIG. 116.

so as to move freely between the poles of the electro-magnet, and are furnished at their lower end with an adjusting weight to maintain the proper balance of the magnet and its index, so that it shall have no bias to fall always to one side. When a current passes through the

electro-magnet from left to right, the needle is thrown over in the same direction, the number of the index appearing in front of the opening provided for it in the front of the case, being retained in that position by the affinity between the magnet and the iron core of the electro-magnet until a reverse current is passed through the coils.

211. Fig. 114 will, in combination with 116, enable the course of the current to be easily traced. Taking the wire No. 1 in connection with the button No. 1, the current will enter the indicator instrument at terminal number one, and thence proceed to the electro-magnet *c*, through which it passes, and proceeds further to the spring *b′*, which is in contact with the piece E, and from thence it goes through the terminal *s* to the bell. Another wire is attached to that in connection with terminal number one before it reaches the electro-magnet *c*, which is carried down to the spring A, which, in the normal condition of the instrument remains insulated. The other wires can be similarly traced, each passing through their separate electro-magnets to the spring *b*, and thence to the bell, and having their own branch wires to distinct insulated springs A A. The positive pole of the battery is attached to the second terminal, +, from whence it proceeds to the plate A′, which is also insulated from E and *b*. The negative pole is connected to the terminal —, and proceeds to the spring *b*, which is insulated and fixed, like *b′*, under the button B. The object of the spring arrangement A, A′, *b*, *b′* is, by the pressure of B, to pass a current through each set of coils in the opposite direction to that followed by the current brought into action by the office buttons 1, 2, 3, 4. Thus the current from the office buttons brings forward the number or name of the office requiring attention, and the current from the *pressure of* B restores the indices to their normal position.

We will now trace the action of the instruments. Button number one is pressed : the current enters the indicator by terminal 1, passes through the electro-magnet *c c'*, throws the index over to the right, displaying its name or number, as shown in Fig. 114. It then passes to spring *b'*, through E and terminal S, to the bell, which it rings as long as the button is pressed. The attendant having heard the bell, sees by the index displayed the office requiring attention, and before leaving his lobby presses the button B, which brings *b'* into contact with A, and therefore with the positive pole of the battery; and *b*, which is the negative pole of the battery, into contact with A, which is in connection with the electro-magnet *c c'*. By this proceeding a current is sent through the coils in the reverse direction to that set in action by the office, which restores the index to its normal position. The stud B actuates all the indices at one and the same time, *i.e.*, a current passes through each of the coils whenever B is pressed, so that if two or more indices are exposed, they are all returned to their position of rest by this one action of the attendant's; but if desired each index may be provided with a separate restorative button, or a certain set of indices may be under the influence of one button, and another set under another.

The indicator may be fixed in one place, the bell in another, and the battery in a third, if desired. The shields or indices may, with equal convenience, indicate the names of individuals whose presence may be required by the senior officer, and thus save time and trouble in despatching messengers to and fro between the offices.

There are other forms of instruments which effect the same object, and which differ mainly in detail or in the form of index. The principle involved is the same.

Single-stroke Bells.

212. Perhaps no form of bell has done more service on railways than the **single-stroke bell.** Walker was the first to introduce them, and the bells employed by him on the South-Eastern Railway were invariably of a loud and full tone, such as bells for signalling purposes should be. The old "tapper" bell of Izant has also

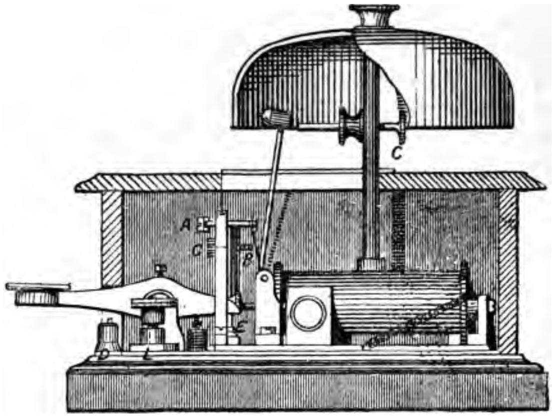


FIG. 117.

seen good service on railways, but, although calculated to work long distances, it lacked that force of sound so desirable for such work. The tapper and single stroke bells designed by Preece are perhaps the most useful, as they emit a fine tone, loud enough for all purposes, whilst they are capable of working through such distances as are necessary for railway-signalling.

Fig. 117 is a representation of the "tapper" form. A

simple "single-stroke" bell would be similar in form and arrangement, with the exception that it would be void of the tapper, or key; and that the coils, bell-dome, and fittings in general would be arranged in the centre of the instrument. In construction both are excessively simple. The key, where used in combination with the bell, is an ordinary single-current key, the front contact D of which is in connection with one pole of the battery, the other being to *earth*. To the bridge or centre of the key is connected the line wire: the back stud E is in connection with the coils, the other end of which is put to *earth*.

The armature is held away from the coils by means of a flat, well-tempered spring, regulated by the adjusting screw G, against which it rests. The play of the armature, and consequently of the hammer which it carries, is governed by the adjusting screws C and A; the latter controlling its backward, and the former its forward movement, so that the hammer, whilst striking the bell-dome, may not *rest* against it, and thereby impair the clearness of its note.

An incoming current will enter at L, pass to the back stop E, and thence traversing the coils, go to *earth*. So long as the current flows through the coils the armature will be attracted, and the hammer caused to strike the bell-dome. On the cessation of the current the hammer will, under the influence of the spring, be carried away from the bell-dome until it rests against the end of the screw C, its normal position. Thus one stroke on the bell-dome is sounded for every current passed through the coils.

To signal to the adjoining signal-box the key has to be pressed down until its lever presses upon D. When in this position the back stud, E, and consequently the coils of the instrument, are disconnected; the back

portion of the key rising in a manner corresponding to the depression of the front portion. On the lever of the key making contact with D, a current will flow from the battery through D to L, and so on to the distant station. For each pressure of the key a current will be transmitted and the distant bell, or bells, in circuit, sounded.

This class of bell is extremely useful for yard purposes, shunting, and other operations which require co-operation on the part of others. It is frequently employed at

FIG. 118.

level crossings or on station platforms, for intimating the approach of trains.

213. Fig. 118 shows the mode of *joining up*. The apparatus at each station consists of a bell-key, bell, and battery. A is the lever of the bell-key, B its upper, and C its lower contact; D is the battery. On pressing A the battery current flows along the line-wire to the distant station, and entering at A′ passes to the stud B′, and through the bell coils to earth. In its normal

condition the line-wire is in communication with the bell and earth at both ends.

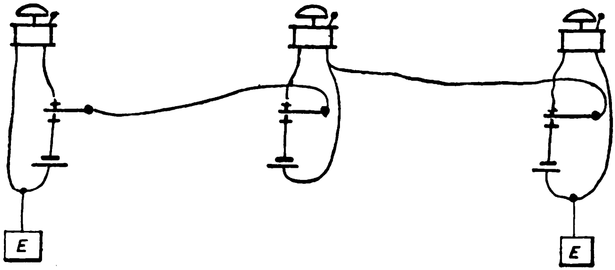


Fig. 119.

It is not usual for the circuit to consist of more than two sets of bells and apparatus, but Fig. 119 shows the electrical arrangement when such is required.

CHAPTER XIX.

POINT INDICATORS.

214. POINTS are occasionally worked at a considerable distance from the signal-box. The greater the distance, the less is the chance of their correct action being *felt* from the lever. In such cases it is quite possible for a stone to get between the point and the permanent metal and prevent the former from being brought into its proper position. Mechanical indicators have been frequently tried, but from the effects of the variation of temperature on the metal rods and wires by which they are worked or locked, and from other causes, they have not been found so reliable as is desirable.

Electricity, on the other hand, is peculiarly qualified to meet what is required. By its aid the movement of any object may be measured with the greatest accuracy, far greater than is needed to record the faithful action, or otherwise, of any set of points.

That facing points are, when unprotected and beyond the actual vision of the man working them, a source of danger, is patent to every one acquainted with railway working, and needs no demonstration here. All points have two positions—*open* and *shut*, or *open* and *closed*—and when in either position should lie close to the sister

metal, so as to form as truly as possible a continuous and firm metal road. Any departure from this is liable

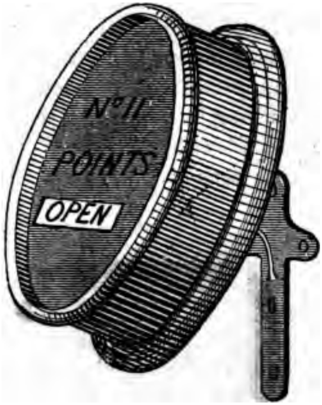


FIG. 120.

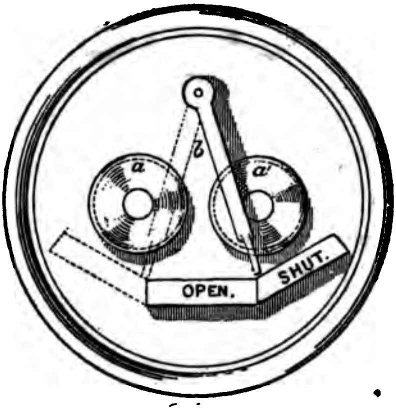


FIG. 121.

to lead to a casualty. It is therefore desirable that the *record should* be such as to afford both these indications,

and to record that required **only when the point is in its proper position.**

215. Fig. 120 is an outside representation of an instrument capable of being applied to this purpose. Internally it consists merely of a pair of coils, *a a'* Fig. 121, with a small permanent magnet, *b*, pivoted at its upper end, and having its lower end extended so as to carry a small shield with the words "open," "shut," printed upon it, as seen in the figure. It will be clear,

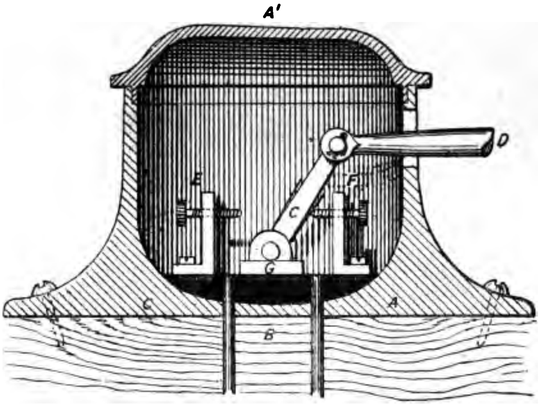


FIG. 122.

from previous explanations of this character of instrument, that a positive current will produce a movement of the magnet, and consequently of the shield, in one direction; and that a negative current will have the opposite effect. Thus the word "open" or "shut" may be brought up to the aperture in the face of the instrument, by the reversal of the current, at pleasure.

216. To produce this reversal in accordance with the *movement* of the points, we require a **commutator**

which shall be actuated by the points. Such an instrument is shown in section by Fig. 122. A is a circular cast iron box some nine inches in diameter, having a movable lid A′, fixed by screws in order to prevent its being tampered with. Upon a piece of metal, insulated one from the other, are placed the two cocks, E, F, and between them an insulated socket piece, G, upon which works the lever C, in connection with a strong rod, D, of from 1″ to 1½″ diameter, which is connected directly with the points to be recorded. Holes are provided through the bottom of the box for the admission of the wires which have to be connected with the insulated pieces, E, F, G. To E is connected the copper pole of a battery, the other pole of which is connected to one end of the coils of the indicating instrument. To F is attached the zinc pole of another battery, the opposite pole of which is also connected to the aforesaid end of the coils of the indicating instrument, and to G is attached the line wire in connection with the remaining end of the coils, all of which is shown in Fig. 123.

The iron commutator-box A, is firmly fixed to a framework of wood, or to one of the transverse sleepers employed for the rails; and the lever C is provided with small flat springs on either side so as to secure a good rubbing contact with the adjusting contact pins in connection with E and F.

217. Now it will be evident that so long as the lever C is in connection with F (Fig. 123), the current will be flowing from battery *a* along the wire *k*, through the instrument, out at *j*, which wire it will traverse and enter the commutator at C, which it will again leave by the contact F, completing the circuit by means of the wire *h*.

If the points are moved over into the opposite

position, we shall have C in contact with E, when the current will flow from battery *b* by way of wire *i*, to the contact stud E, lever C, wire *j*, entering the instrument at this point and completing the circuit by means of the wire *k*.

But should the points not go home, the lever C, will fail to make contact with either of the studs E, E, as the case may be; no current will flow through the coils, and the indicator instead of exhibiting the word "open" or "closed" will exhibit a portion only of each, making no signal at all, or rather a confused indication only.

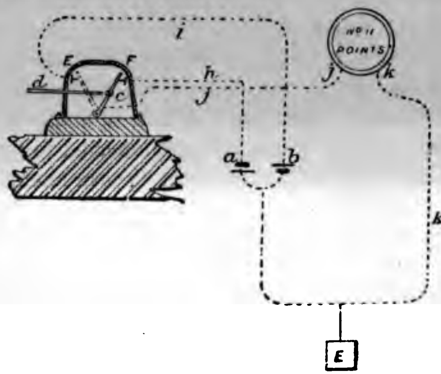


Fig. 123.

The indicating instrument should be fixed immediately behind the lever which works the points, and the commutator as near as may be convenient to the points themselves. When placed in the four foot it should be so arranged that a loose carriage coupling shall not strike the box, as such a blow might possibly break it. If desirable, however, the rod in connection with the points may be carried any reasonable distance so as to place the

commutator out of the way of shunting operations; but wherever the distance is such as to admit of any appreciable expansion or contraction of the rod from atmospheric causes, compensation levers should be inserted.

Such a commutator as that described is useful for many purposes, as, for instance, for automatically intimating at certain points the approach of a train—a treadle being used to actuate it in the place of the points.

Level Crossings.

218. It is desirable that the gate houses or gate boxes of all level crossings should be provided with a means by which the gate-keeper may receive intimation of the approach of trains.

This is usually effected by inserting a single stroke bell on the bell or signal wire used for block purposes; but where there are three or four such crossings within the same section it is advisable to employ a small relay at the crossing boxes, and by its aid work the bell fixed there, in a local circuit. When this course is pursued the signals are stronger and large trembling, instead of single stroke bells, may be employed. More than one trembling bell cannot be employed, in the same circuit, with satisfaction, as it is difficult to secure a perfectly synchronous movement of the armatures, and without this the make-and-break arrangement of the one would tend to interrupt that of the other.

219. A very simple form of *relay* is all that is required. It may consist of one or two small coils; the armature of which, when attracted to the cores of the coils by the passing current, shall complete the local circuit. Such an arrangement is represented in Fig. 124. A, B are the sectional block signal stations, and C, D, level crossings;

a, *b*, the bell keys at the former, and *c*, *d*, the relays at the latter. If the spring of the bell key at *a* is pressed, a current will flow along the line wire, passing through the relays *c*, *d*, the armatures of which will be attracted, and the local circuits completed during the passage of the current. If one current only is sent from A to B only one stroke will be rung on the bell at C, and one series of rings on the bell at D; the bell at *c* being a single stroke bell, and that at D a large trembling bell. Should B ring to A precisely the same effect would be produced. As the armatures of the relays are not polarized it is

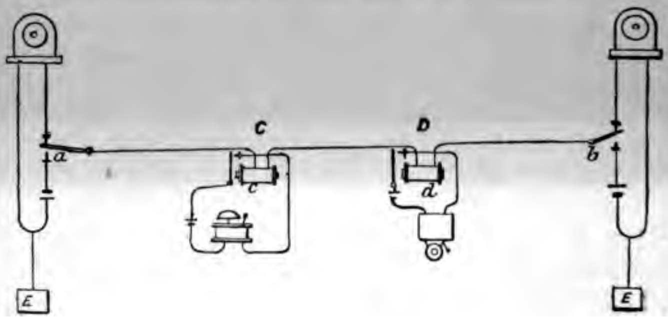


FIG. 124.

immaterial whether the current from either of the terminal stations is positive or negative — the attraction of the armatures, and consequently the closing of the local circuits, will be the same in either case.

It will be observed that in neither case has the level crossing any power over the signals, nor can they be interfered with by the gateman. He simply hears the signals passed upon the wire, and, being acquainted with the code in use, readily recognises the *departure*, from *other signals.*

Yard Working.

220. It is almost impossible to indicate the various requirements of a busy station-yard service. Nor are they to be dealt with by rule, for that which is perfectly applicable in one case may be wholly unsuitable in others. What is required should first be ascertained. This done it is easy to meet the want.

Generally, however, it will be found that some means of communication between the ground-men, shunters, and others, and the signal-box which has command of the yard points is necessary. Despatch is thereby secured, much shouting avoided, and a greater degree of safety obtained.

Some central or convenient point should be selected to which the yard foreman or shunter should have access, and here a bell and bell-key should be fixed, communicating by wire with a similar arrangement in the signal-box. By the use of a code of signals the shunter's wants may then be made known to the signalman, and if all is safe for him to proceed with his work an *all clear* signal may be sent him from the signal-box, the signalman there setting his signals and points accordingly. The bell and bell-key may be placed within a small box, fixed, upon a lamp post or other convenient support; or the bell may be placed in a box with holes bored in it to afford free emission to the sound, and the bell-key in a smaller case within easy reach of those who have to use it. Such a box or case should be provided with the ordinary carriage-door lock. The single-stroke bell should be used.

221. Much convenience frequently attends the employment of similar arrangements between busy station

departure platforms, and the station or yard signal-box. Intimation of the readiness of the train to depart can be signalled a moment or so before such is absolutely the case, and on receipt of the clear signal the train can be started. Where the traffic is irregular such a system is of great advantage in facilitating the yard work, as under it there is no necessity for stopping conflicting work until the *warning*, or the *train ready* signal is received.

Platform Bells.

222. Reference has already been made to platform

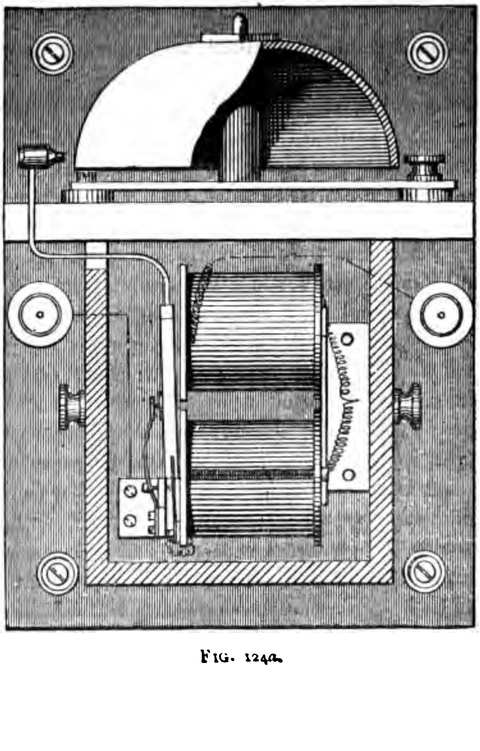


FIG. 124a.

bells under § 208. Such bells are now recognized as a necessity at all busy stations, and are generally worked from the station signal-box. When so worked the large trembling bell, Fig. 124*a*, is the best suited to the purpose, but where the bell is inserted in the block-signal bell-wire a single-stroke bell must be used, unless a relay is employed to work it. The former arrangement is to be preferred as it involves no unnecessary or superfluous ringing which is inexplicable to the passengers. A platform bell should be regarded much in the place of the hand bell, and should be rung on the near approach of the train—up stopping, down stopping, up through, and down through trains, all being indicated by a recognized code applicable to the entire service, so that passengers as well as officials may become acquainted with it, and thus, each alike, be prepared for the arrival of the train.

Where trembling bells are used the bell-key should be pressed somewhat longer than is usual for ordinary block signalling purposes, and the pauses between the signals should be of greater duration, so as to render the *series of rings* on the bell more durable and distinct.

Movable Bridges.

223. Wherever movable or swing bridges intersect a line of railway, the maximum of security is only to be

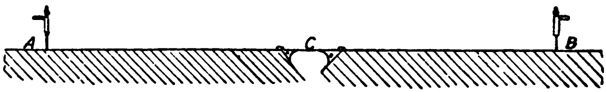


FIG. 125.

obtained by the employment of block signals and inter-

locking frames for the section of line over which the danger exists.

Let A, Fig. 125, be one station, B the adjoining station, and C the movable bridge between them. If the line is worked under the block, then such block signals should be so arranged in connection with the bridge, that when it is in any other position than that suitable and safe for a train to pass over it, the block signals for trains approaching from either A or B shall stand at danger. Where the line is not worked under the block, then it is desirable special communication should be provided similar to that explained under siding working, § 187.

224. Thus the **points to be secured** are—

1. That the officer in charge of the bridge shall under no circumstances unlock it with a view to opening it for the water traffic, without the concurrence of the signal station on either side.

2. That before doing so he shall block the roads on either side of him, and only on receipt of the acknowledgment *that they are blocked* shall he proceed to open the bridge.

In addition to this, as a further precaution, the lever locking the bridge gear should interlock with signal levers, so that before the bridge is opened, the line signals, worked from that point, must be set to danger. The bridge would thus be protected by the station signals on either side and by the signals at the bridge itself.

225. We will assume that the line is worked under the block system, and in the first instance that the system in use is a three wire system.

Of all three wire systems Preece's is the most suitable for the work, inasmuch as with it the danger signal being produced by gravity and the all clear signal by the action of the current, we have in this arrangement the element of safety, viz., *the absence of the agency by which the all clear signal is produced resulting in the danger signal*, and *the active presence of the agency employed resulting in the production of the all clear signal*, a result highly desirable where neglect, oversight, or accident are calculated to produce casualties of an alarming nature. In all such cases the advantage of the all clear signal being produced by the

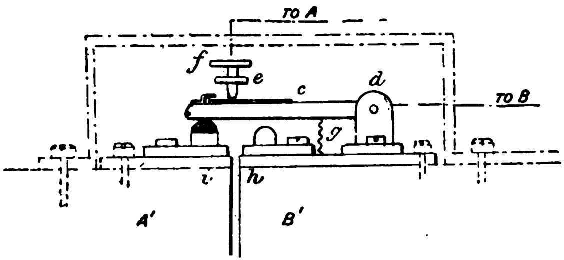


FIG. 126.

presence of the agency by which the signals are worked, is too evident to require remark.

226. Dealing then with Preece's, or any other system under which *the danger signal is produced by gravity*, and the all clear signal by the constant action of the current, all that is needed is that the bridge shall, when in the least removed from its position for railway traffic, break the semaphore, or block line-wire circuit. Thus, let A' Fig. 126, represent one end of the bridge, and B' that portion of the permanent-way adjoining it. At B'

placed a commutator or key having a lever *c*, centred at *d*, and an upper contact piece *e*, with adjusting screw *f*, the lever *c* having a downward inclination under the influence of the spiral spring *g*. At *h* is an insulated stud which limits the downward movement of the lever.

At A′ is placed an insulating pin, *i*, in such a position that when the bridge is in its true position, it shall press upon and lift the lever *c* from the stud *h*, and bring it into contact with the adjusting screw, *f*, of the cock *e*.

The block-signal line-wire is then divided, and one portion connected to the lever *c*, and the other to the cock *e*.

If now the bridge is the least depressed, or the metals are not in their true position, the stud *i* will not engage with *c*, and, impelled by the spring *g*, *c* will not form contact with *f*, and thus the line-wire will be interrupted.

One such contact arrangement will be requisite for each wire to be interrupted. Thus taking that represented to apply to the signal for trains from B, the line-wire B would be carried to the semaphore block signal there, and the line-wire to A to the switch at A working the block signal at B.

The other contact arrangement would be similar, but the line-wires would be connected up in the opposite manner, so that the line to A would be joined to the semaphore governing trains proceeding to A, and that to B, to the switch working the semaphore at A.

The contact arrangement should be strongly made and protected from the weather, or from rough usage, by an iron or thick wooden cover.

227. With block signals where the *danger signal is produced by a constant current*, as in the double needle

system, the contact arrangement must be of a somewhat more complicated character, as it is necessary when the bridge is in one position to complete the block signal circuit, and in the other case not only to sever it, but to interpose at the point of severance, a battery current of sufficient power to operate the signals at either end. In this case the arrangement will be that symbolically represented in Fig. 127. The lever in this case is extended on either side of its centre, and insulated at *a*. When in the position represented in the figure, the line wire is complete, by means of the contact studs *b*, *c*; but when the bridge is out of position, and the lever assumes the

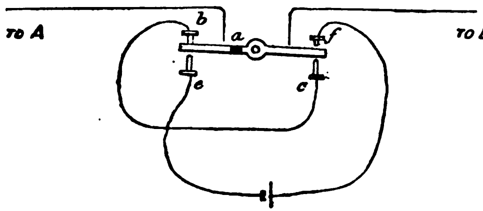


FIG. 127.

opposite position, the line wire is severed, and the battery *d*, interposed at the contact studs *e* and *f*. The line wires are in connection with the two portions of the lever.

A three wire block system is, under all circumstances, the most desirable for the purpose; but the arrangement shown in the last figure is also applicable to a *one wire system*, the connections at the adjoining signal boxes coinciding, with regard to the battery connections, with those of the bridge commutator; thus, in order to place the block signal at A at danger, B must employ a zinc current, and to place the signal at B at danger, A must make use of a copper current.

228. *When the block system in use is a single wire system*, the block signal produced by the movement of the bridge should be the result of a constant current as represented in Fig. 127, so that there may be no possibility of any change being made in the indication of the signal, from atmospheric or other causes.

229. Whatever the system employed, whenever the bridge is under the charge of an officer other than the signalman at A or B, such officer should have block signal communication with the signal stations on either side similar to that advocated for siding working (§ 187); That is he should be able to block both sides of him, and to ask permission, by bell signal, to open the bridge, such permission being confirmed by an indicating (visual) signal, so that no possible misunderstanding may arise.

The course of proceeding would thus be—

a. The officer in charge of the bridge would intimate his desire to open it by a concerted bell signal.

b. If all were clear for him to do so, the signal box communicated with would intimate such by the all clear signal.

This proceeding having been repeated to the station on the other side—

c. The officer at the bridge would proceed to block the stations on either side, and

d. When this was confirmed by the recognized acknowledgment of the block or obstruction signal, he would open the bridge.

If the line is worked upon the block system, the displacement of the bridge will also place the ordinary block signals at danger, confirming the local action of *the bridge* officer.

Train Describers.

230. The object of a *Train Describer* is to give information of the description of approaching trains to certain points, at which such information is necessary in order to enable the officer at that point to dispose of them with despatch, and to place them in their proper position. For instance,—B has the disposal of all trains entering a station yard. If he is made aware of the character of the approaching train he is able to set the points so as to run it direct into its proper siding, or platform, without stopping or checking it in order to learn where it is for, or what it is; whether empties, an engine only, or a main-line, or branch train.

An instrument, such as that described under § 210, may be employed for the purpose, but it would require an independent wire for every two indications. It would, however, possess this advantage. Each indication would be certain, and any possibility of confusion arising from a wrong signal would be avoided. With single wire "describers," the indication must be produced by a step by step movement, the absence or loss of any one current causing the indicator to fall behind one step or one indication, and consequently to stop one indication, or space, in the rear of that required to be indicated.

231. Figs. 128 to 131 represent an instrument, designed by Mr. C. V. Walker, of the South-Eastern Railway, for this purpose. It is worked by a single wire, and is consequently based upon the step by step principle.

232. Fig. 128 gives an external representation, and Fig. 129 the internal arrangement, of the *Sender*. The wheel B is driven by clockwork contained within the frame A. This wheel is provided with 12 metal pins, which

project from it at right angles in such a manner as to intercept, as it revolves, the insulated spring C: the motion being in the direction indicated by the arrow.

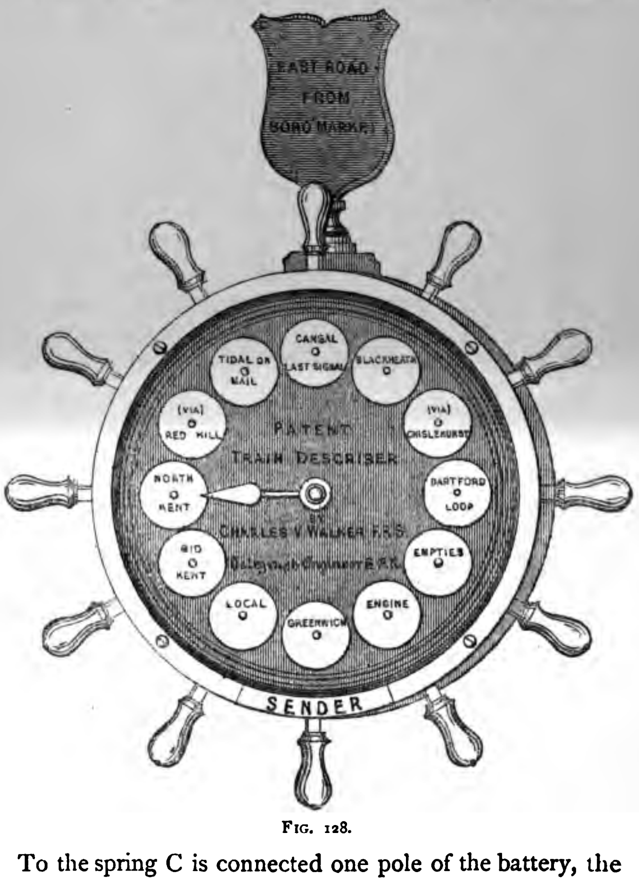


FIG. 128.

To the spring C is connected one pole of the battery, the *other* being to earth.

The sending instrument is provided with twelve handles, capable of giving twelve distinct signals. Each signal is rendered by drawing over, towards the operator, the handle opposite the signal required to be indicated, and thrusting back into its position of rest that last

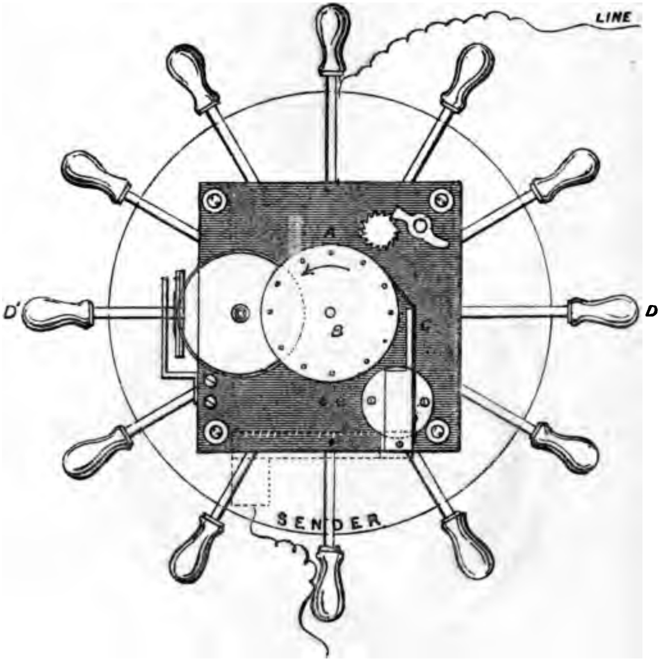


FIG. 129.

brought forward. The replacement of the latter releases the clockwork, and so causes B to revolve until it arrives at the handle which has been drawn over, by the displacement of which its motion is arrested. Supposing now the last indication made to have been by the handle

D, and that it is required to transmit another signal represented by D′. To do this the wheel B has to pass through half of a complete circuit, the space occupied by six handles. In traversing this space it will press six

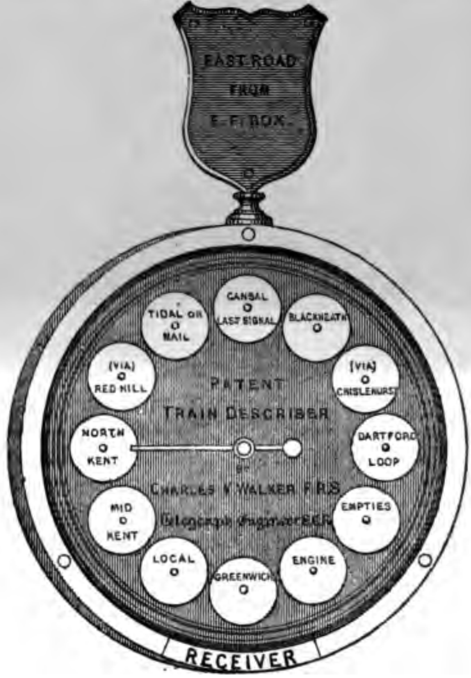


FIG. 130.

of the projecting pins with which it is fitted against C, and thus transmit six impulses or currents to the receiving station.

233. The *receiving instrument*, Figs. 130, 131, has

within it an electro-magnet A, to the armature of which is fixed a ratchet arrangement, *d*, which, when moved backwards and forwards, impels a small ratchet wheel, *c*, which has on its axis an indicator such as is shown in Fig. 130.

234. The *method of working* consists merely in first pushing back, into its position of rest, the handle last

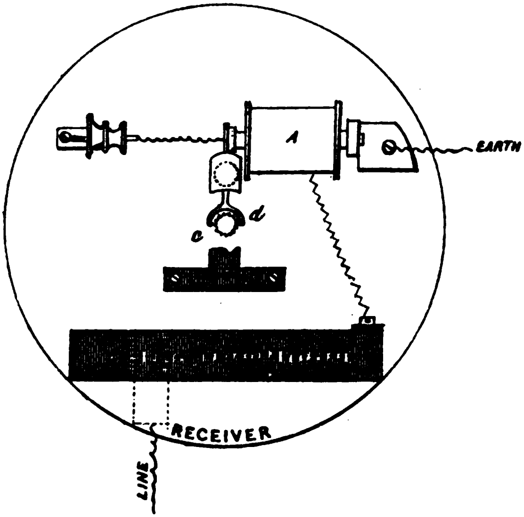


FIG. 131.

used, and then drawing over that which indicates the signal required to be rendered. This handle must then rest there till another signal has to be made; otherwise the mechanism would continue to revolve until run down. It is the replacement of the handle which starts the machinery, and the displacement of any one of them which stops it.

CHAPTER XX.

LIGHTNING PROTECTORS.

235. LIGHTNING is a fruitful source of faults upon telegraph circuits of all descriptions, whether employed for speaking purposes or for block-signalling. Underground lines, where unconnected with open—that is aërial wires, are more free from its injurious effects. Some form of lightning protector is therefore necessary in order to prevent what would otherwise be the case, the fusion of the wire composing the coils, or other derangement of the instrument.

Several forms of lightning protectors have of late years been introduced, tried, and abandoned. Those known as the "reel," and the "carbon and boxwood" are no longer issued by the Postal system, although still very generally used on railways.

236. The former of these, the "reel" protector, consists of two insulated wires, usually covered with silk of a different colour, to distinguish the one from the other; twisted together, and wound upon a small reel of boxwood or metal, the latter, when employed, being connected with the earth. The wires are still further protected by being passed through melted paraffin, in order to prevent any leakage between them from dampness.

To one end of one of these two wires is connected the up line wire, and to the other the wire leading *to* the coils of the instrument. To one end of the other, the wire leading *from* the coils of the instrument, and to the other end the earth, or down line wire, is attached. Thus the line wire and the earth, or the up and the down line wires, are brought within close proximity to each other, being separated only by the silk covering of the wire and the thin coating of paraffin through which the wires have been passed. The object is that any high charge of atmospheric electricity, of sufficient intensity to damage the instrument, shall pass through the insulation of the twisted wires in order to get to the earth and so escape the coils. But where this takes place the protector is almost invariably sacrificed, the twisted wires being usually left in contact, thereby cutting the instrument out of circuit.

237. The "**carbon and boxwood**" protector consists of two insulated brass or copper rods, fitted within a boxwood case, the opposed ends of the rods within it being pointed, and so fixed that their points shall be $\frac{1}{20}$th of an inch asunder. The interior of the case is filled with a mixture of carbon and non-conducting matter in the form of a fine powder. To the metal rods are attached the in and the out wires of the coils. The protector thus acts as a shunt or short circuit, having a very high resistance compared with the coils, such that whilst preventing any appreciable diminution in the strength of the battery current, it shall, in the case of a discharge of atmospheric electricity of a high tension, afford a passage for it between the points of the metal rods and the intervening mixture of carbon between and around them. It has not unfrequently happened that the particles of carbon have become polarized, and

have thus practically placed the instrument on short circuit. This is remedied by shaking or tapping the protector so as to disturb the arrangement of the particles within it.

238. Each of these forms is now being fast superseded, in the Postal telegraph service, by what is termed the "**cylinder**" protector. Two wires, insulated with silk, are wound around a brass cylinder, which cylinder is connected with the *earth*, the wires being connected with the instrument wires as explained in § 236. This is a form of protector which also frequently obtains its object at the cost of its own destruction, as the wires become fused, or their insulation destroyed, much the same as with the "reel" protector.

239. The "**plate**" protector, which is coming very generally into use on Postal circuits, is probably the most useful and reliable. It is formed of two metal plates some two inches square, placed close together one above the other, but prevented from absolutely touching each other by the insertion of either thin ebonite washers, or a piece of paraffin paper. The opposing surfaces of the plates are serrated at right angles to each other, and thus present a number of small points which promote the discharge. One of the plates is connected to the line wire, and the other to the earth.

The inner surfaces of the plates should be kept clean and free from dust. The paraffin paper when employed should be examined after every thunder-storm, and even at other times occasionally; and if there is any indication (usually in the shape of a hole burnt through the paper, which may be readily recognised by holding the paper between the observer and the light) of a discharge having taken place, it should be replaced by a fresh piece.

240. Usually protectors are fitted to the instruments themselves. The examination of the protector thus involves the removal of the case, and not unfrequently of the entire instrument; which may not always be convenient, especially with block signals. *If fixed apart from the instruments, they would be equally serviceable*, might be examined at any moment, and if necessary replaced or refitted without in any way interfering with the working of the apparatus. The apparatus at every telegraph office or signal-box should be thus protected.

Switches.

241. Switches serve the same purpose for electrical circuits as do points for railway roads. By means of the one the electric current is shunted on to another wire in the same way, as, by means of the "points" of a line of railway, the traffic is diverted from the one line to another.

Under block-signalling, § 112, mention has already been made of the term switch. The instrument spoken of is equally as much a switch as is that which has now to be described, in that, by it, the line wire is switched from the earth wire to the battery, or *vice versâ*. The term switch in its general application, however, applies to an instrument by which the arrangement of the circuit may be altered at will: thus, a branch circuit which is usually terminated at the junction station, may be put through to a main line or other more important office, or a block circuit may be put through from A to C during the night, when the sectional box, B, is not required to be open, and by which the normal day arrangement may be readily restored when B opens for work in the morning.

242. Switches for this purpose are of different make

The "**pin switch**" is that shown in Fig. 132. Such a switch is available for putting a wire through from, say A to C, or for terminating it at B. It is formed of four plates of brass fixed upon a piece of ebonite with a small space between each. Midway between these plates holes are drilled capable of receiving the connecting pin, the lower portion of which is formed of a round piece of brass

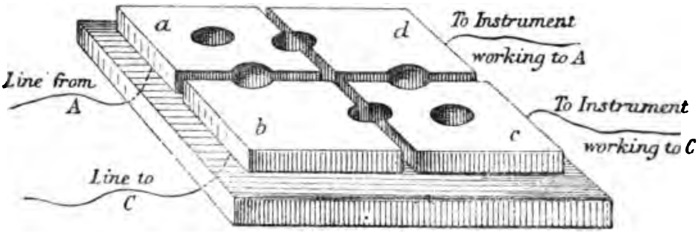


FIG. 132.

with a slit in it to give greater elasticity and biting power. The connections are as shown in the figure. By placing the pin *e* in the holes between the respective segments *a*, *b*, *c*, *d*, the wires in connection with them are brought into circuit and the line wires either connected to their respective apparatus, or joined through direct.

The divisions between the plates should be kept free from dust, and the socket holes should be truly cut, so as to secure a good contact between each plate and the pins.

243. The "**Tumbler switch**" is still, and very justly so, largely employed, especially where more than one wire has to be manipulated at the same time, as would be the case in altering the course of a double-needle circuit, or of a three-wire block system. Fig. 133 illustrates its action, *a* is a strong spring lever, centred at *c*, whose action is limited by the adjustable contact screws *d*, *e*.

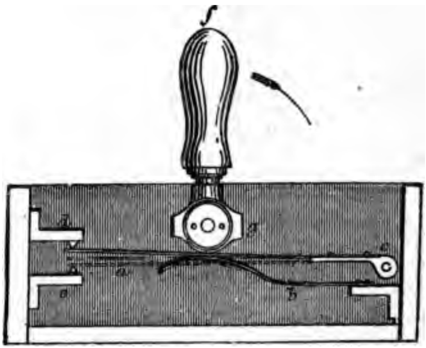


FIG. 133.

The lever, *a*, is acted upon, first by the spring *b*, which tends to raise or press it against the upper screw *d*; and by an eccentrically arranged barrel *g*, which carries upon its shaft a handle capable of assuming one of two positions—vertical and horizontal. When in the vertical position *a* is in circuit with *d*, and when the handle is turned down to the horizontal position, it is in contact with *e*.

Fig. 134 gives the electrical connections for dividing and putting in circuit two terminal sets of two-wire

apparatus, or for putting the two line wires through, leaving the terminal instruments disconnected. When the levers are in the position shown the line-wires are terminated through the instruments at B. When they are depressed the line wire *a* is placed in connection with *a′*, by means of the connecting wire *a a′*: *b*, in a similar way, becomes joined to *b′* by the connecting wire *b b′*.

It will be evident that any number of combinations may be provided for in this way. Main line circuits may be divided, and branch circuits switched on to the upper or lower portion; or one branch circuit may be switched through to another at will.

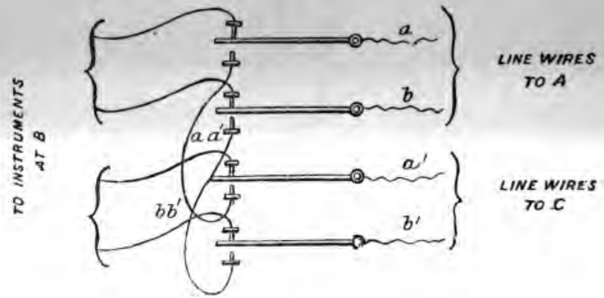


FIG 134.

The contact points of these switches require to be looked to occasionally. They should be carefully scraped and kept clean, as they sometimes become oxidised.

244. A very simple, and a very good switch, where it is in the hands of a reliable man, is **the movable bar switch** shown in Fig. 135. *a*, *b*, are two flat pieces of brass cut to the shape of G. A, B, B′, C, are ordinary instrument terminals fixed to small blocks of brass arranged at equal distances from each other upon a

base board. Each terminal is named according to the station or line with which it communicates, and the plates *a*, *b*, are inscribed "THROUGH TO." The plate *a* is capable of gripping the terminal B, or the terminal C; and plate *b* of gripping C or B. A and B are the centres upon which these plates work. It is clear then that if it is desired to put A through to B, and C to B′, the plates must be arranged as in the figure; but if it is required that A should be put through to C, then *a* must be removed from under the terminal B, and

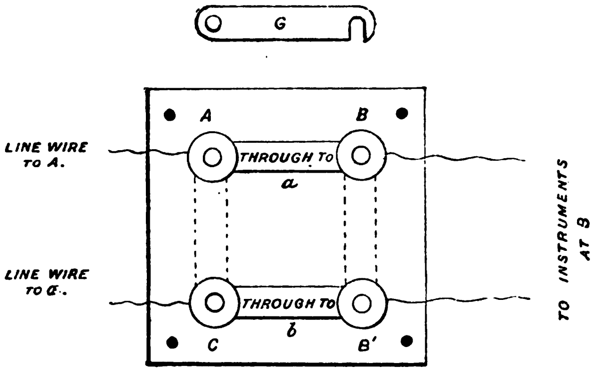


FIG. 135.

b replaced by it at C. In this case as B, B′, communicate with the two sets of instruments at B, it is not necessary that the plate *b* should be connected to B; but when such is the case it affords a means of testing the efficiency of the connection, as the two sets of instruments, being in circuit, can then be worked from the same box.

The plates require to be firmly screwed down whenever their position is changed.

CHAPTER XXI.

INTERCOMMUNICATION IN TRAINS

245. In 1867 a circular was issued by the Board of Trade to the Railway companies, asking them to confer on the subject of passenger and guard communication.

In 1868, an Act was passed, ordering that after the 1st of April 1869, every train travelling over twenty miles without stopping should be provided with a means of communication between the passengers and the guards of the train.

In February, 1869, the Board of Trade allowed the *cord* system—a mechanical arrangement—to be adopted, *conditionally*.

In August, 1872, Captain Tyler, in a report upon the subject, addressed to the Board of Trade, says, "the result of the working of the cord system has not been satisfactory," and in his report of August, 1871, shows that it is "hardly an economical system, though cheap in first cost."

Captain (now Sir Henry) Tyler thus sets forth the requirements of such a communication.

"The apparatus, of whatever nature, shall be as far as possible simple and self-adjusting; it shall, after disuse for a length of time, be efficient when tested; it shall

appeal unmistakably to the eye and ear of the driver on the engine, and of the guard in each part of the train; it shall be equally efficient in very long or in short trains; shall be adapted to the attachment or detachment of carriages on a journey; shall be independent of the state of the rails or the state of the atmosphere; and, while not liable to be accidentally set in motion, shall be easily acted on when required."

"An electrical apparatus appears on the whole to offer the best chance of success."

The systems of electrical communication which had been introduced in 1873 were four, viz.:—

1. Preece's, introduced on the South-Western Railway in 1864.
2. Walker's, introduced on the South-Eastern Railway in 1866.
3. Varley's, introduced on the North-Western Railway in 1866.
4. Binney's, introduced on the Great-Eastern Railway in 1872.

The principle of Preece's and Walker's is identical, inasmuch as each instrument has a battery, the similar negative poles of which are joined to a connecting wire running throughout the length of the whole train, whilst the opposite or positive poles are connected with the earth, thus setting up a state of electrical equilibrium which may be disturbed at will by placing the train wire to earth, when the current from each battery will pass through the instruments in connection with it.

246. Of the systems mentioned there now remain but two in practical use, viz., Walker's, on the South-Eastern Railway, and Preece's, on the London and South-Western. The former railway may be said to have been the pioneer in the thorough adoption of electrical

train communication; for in the face of the very general preference expressed by the railway companies' representatives for the cord system, it yet adhered to the electrical, and at the present time the greater portion, if not the whole, of its passenger rolling-stock is fitted with it.

247. The **desirability of a uniform system** will be evident to the most casual observer. The connection between the various railway systems is now so complete, that the interchange of coaches between system and system is a frequent occurrence. If one system were worked upon a method entirely different in its principle to that adopted on any other line, it is evident that to afford the occupants of a coach belonging to such system, travelling over another system, its advantages, some special provision would have to be made. It is thus that a uniform system is desirable, and this extends not only to the principle upon which it is worked, but also to the method of coupling-up the coaches and other vehicles which may be introduced in the train.

Preece's System.

248. The principle involved in this system is illustrated by Fig. 136.

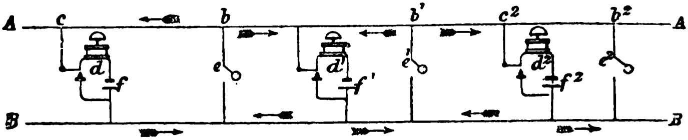


FIG. 136.

A is a wire passing throughout the train, b, b', b^2 are branch wires from it to commutators e, e', e^2, which are also in connection with the "earth" wire B. At c, c', c^2,

are similar branch wires communicating with a bell, the other side of which is in connection with the zinc pole of a battery, the copper pole of which is to earth. From either side of the bell wires are led to commutators d, d', d^2, which, in common with those at e, stand, normally, open.

Now if all the batteries are of equal power, and no leakage between the wire A and the earth exists, no current will pass, for the several forces will be in contention as represented by the arrows, and naturally, if the equilibrium be true, no influence will be exerted on the apparatus. But now let the commutator, e', be turned so as to bring the two wires, in connection with it, together. The equilibrium will be at once destroyed, and the battery current from f^2 will find a circuit through e', b', c^2, and the bell, which it will ring. The current from f' will in like manner pass through e', b', c', and its bell, which it will also ring; whilst f will also find a similar circuit, ringing the bell in connection with it. Thus each bell will be actuated and set in motion by the single connection at e', and the same would be the case if either e or e^2 were operated.

In order to apply this to a railway train we have but to imagine b, b', b^2, to be carriages, and c, c', c^2 the engine and guards' vans composing the train. Each van is fitted with a communica tor, d, d', d^2, so that the one guard may communicate with the other or with the engine-driver. This communicator is usually a bell-key (§ 114), which is connected up as shown in Fig. 137. Normally the lever of it forms contact with the upper contact g. On being pressed down however it leaves g, and makes contact with h. In this condition the battery f and its bell are disconnected, and the line wire, A, placed in circuit with the earth B.

In practice, but one wire is used; the metals or earth being employed for the return wire. In order to insure a thoroughly reliable connection between vehicle and vehicle, a double connection is employed, the through wire being forked to meet it as shown in Fig. 138. The

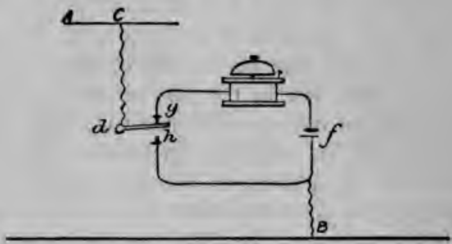


FIG. 137.

line wire is continued through, at either end terminating in a metal loop or eye, and the forked or branch wire therefrom is terminated by a hook: the hook and loop being arranged on alternate sides of the vehicle so as to be opposite each other let the vehicle be turned in either direction.

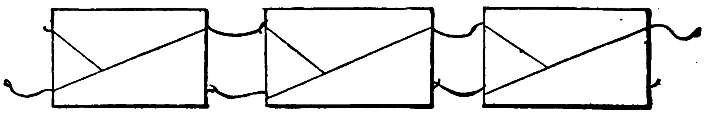


FIG. 138.

The **fittings** comprise:

A commutator fixed in the carriages.

A battery and bell-box fitted with ringing key for the guards' vans.

Engine-signal.

Coupling-ropes.
Coupling-hooks.
Slip or break-away coupling.

249. Fig. 139 is an outside representation of the **commutator**, which is usually provided with a double

FIG. 139.

face so as to admit of its being fixed between the compartments of a carriage, and thus to be accessible from either. A coach comprising four compartments thus requires two commutators. The face of the commutator is protected, or not, as may be desired, with glass or

paper, which has to be broken before the handle can be reached. The advantage of such a protector is that it acts as a deterent to the mischievous, inquisitive, or nervous, and causes them to hesitate before raising a needless alarm.

The handle *a*, Fig. 140, is fixed upon a metal barrel insulated on either side, and which extends through the instrument to the handle fixed at either extremity. This barrel turns with the handle *a*, in the direction of the

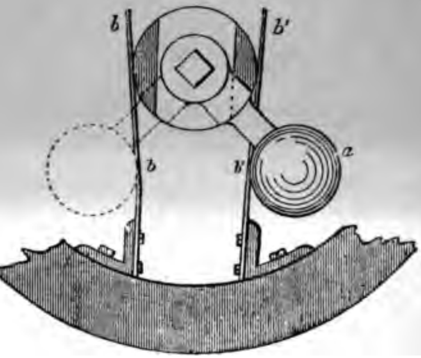


FIG. 140.

arrow, and in doing so brings the two springs *b*, *b'*, to which are attached the line and earth wires, into metallic contact the one with the other, and thus places the line wire in circuit with the earth. When the handle is in the dotted position it becomes locked, and the connection between the line wire and the earth is thus made permanent until the train is stopped and the handle restored to its normal position by the guard, who carries a key for the purpose of unlocking the handle.

The handle when in its normal position covers the locking key-hole, which thus becomes hidden from view.

250. The **van fittings** comprise a bell and battery, fitted within a box, with a ringing key, the whole arranged in a portable form. The bell dome is fitted on the top of the case and is struck from within: it is protected by cross-bars of thick brass. Within the box is the electro-magnet and other portions of the ringing gear, as also the battery, the cells of which are sealed, to prevent the liquid from slopping.

251. The **bell** is merely a trembling bell (§ 208), provided with a secondary armature which in its position of rest locks the ringing armature, and so prevents its vibration under the motion of the train. Immediately on the passage of the current through the coils, however, the secondary or locking armature is withdrawn, and the ringing armature is then free to act under the influence of the current.

252. The **ringing-key** is fixed in the front of the box. It is in principle an ordinary Bell-key or Plunger (§ 114), having a limited movement, and sunk somewhat in the lid so as to prevent its being unnecessarily or accidentally pressed.

The bell, ringing-key, and battery are connected up as shown in Fig. 137, and the two connections, line and earth, are carried up to two brass hooks, fitted to the back of the box, as a means for suspending it, and at the same time forming a connection with the train-wire and earth, which in their turn are brought up and fixed to two springs within a metal bar fixed in the van, which receive the hooks of the battery box.

253. The **engine-signal** is a trembling bell provided with the locking armature, previously referred to in § 251, inclosed in a strong brass case. The face of

it is provided with a small flap, which when the bell is rung is released and falls down, presenting to the view of the engine-driver the instruction "STOP."

254. The **engine communicator** may be in circuit with the whole of the train apparatus, or with the first van only.

255. The **coupling-ropes**, Fig. 141, are formed of three stranded copper wires, *e*, insulated with india-rubber *d*, and covered with a thick plaiting of hemp. To the insulated wire is attached the eye *c* required to make the connection with the hook A on the next carriage. This hook is made of brass or gun metal, and is provided with

FIG. 141.

a stiff flat spring, *a*, which keeps the eye *c*, pressing firmly against the hook-piece A, and so insures good metallic contact. The hook-piece A is securely fastened to the buffer-beam of the vehicle, as is also the coupling-rope B, the end of which is formed into a knot, Fig. 142, so as to prevent its withdrawal from the cap F, which is provided with a hook G, for the accommodation of the eye terminating the rope, when not in use.

256. Fig. 143 represents the **slip** or **break-away coupling**, which may be used at discretion. Where *employed* it takes the place of the hook B, Fig. 141. The

stud C is connected to the earth-wire, and the line-wire to the hook A. This hook works upon two bearings and is impelled, by a powerful spiral spring, to rest against C.

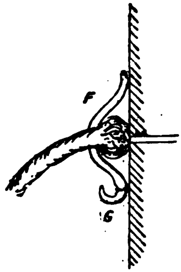


FIG. 142.

From this position it is forced by the eye B, which when in position is held between A and the shoulder A′. Should the carriage break away A will be pulled

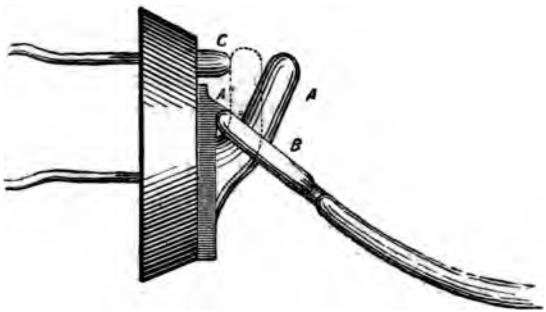


FIG. 143.

down, B will be released, and A will then fly back, making contact with C, thereby placing the line in connection with the earth and starting the bells ringing.

As this will occur with both couplings (Fig. 138) the bells in both portions of the train and that on the engine will be set ringing, and continue to do so, so long as A remains in contact with C.

Electrical Rope Communication.

257. Recognising the necessity of some means for establishing a temporary mode of communication, such as can be attached to a made-up train at a moment's notice, Mr. Preece, in conjunction with Mr. C. Goldstone and others interested in the subject, have devised an **electrical rope** communication, which can be applied to

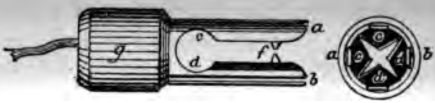


FIG. 144.

a train with all the facility and expedition attending the application of the ordinary mechanical rope arrangement.

In the system just described, but one line wire passes through the train, the rails and earth being used for the return wire. In the *electrical rope system* the metals and the earth are replaced by a wire. The "rope" is thus formed of two insulated wires, which are covered with hemp in the usual manner, and which, when thus laid up, form a rope of some quarter inch in diameter.

258. The rope thus arranged is divided into sections of a carriage length, the extremities of which are fitted with connecting pieces or *couplings* similar to that represented in Fig. 144.

a, *b*, are two flat springs fixed to a hollow block of ebonite, *g*, which is secured by a sheathing of tin. To each spring is fitted a three-sided piece of ebonite, *c*, *d*, somewhat reduced in substance at their extremities; and on the alternate side of each of these is fixed a surface piece of brass terminating in a raised point, as seen at *f*. The communicating wires are brought through the ebonite block *g*, and attached, one to each of the metal surface pieces.

The tendency of the springs *a*, *b*, is towards each other, and thus when nothing is interposed to prevent it, the contact points at *f* are in metallic circuit.

But if now a similar arrangement be presented to that described, in such a manner that its fangs shall intersect those of Fig. 144, and they be forced together, the contact studs will become separated, owing to the ebonite parts *c*, *d*, being thicker at the end at which they join the block *g*; and their arrangement will then be that shown in cross section of the figure; that is, the metallic plates of each coupling will be in contact with the similar metallic plates of the other, whilst the contact *points* will have become separated. The two wires by which the communication is maintained will thus be made good at each coupling.

The fang pieces to which the wires are attached being somewhat tapered towards their ends, it is evident the tendency of each coupling-piece would be to disengage itself from its fellow piece. This is provided against by the metal surface of each fang being provided with a groove and a corresponding projection, which intersect them at right angles about midway. When the two coupling-pieces which make up the complete coupling are forced together, these projections and notches engage with each other and hold the two parts sufficiently firmly

together to require the exercise of a moderate force to withdraw them.

With such a system there is, of course, the possibility of the two wires becoming crossed in coupling-up. This is only material so far as it affects the guards' vans, the bells of which will give instant notice of any such derangement. The remedy is to undo one coupling and reverse its connection, that is, instead of placing *c* (Fig. 144) in contact with *d'*, and *c'* with *d*, to place *c* in contact with *c'*, and *d* with *d'*.

Fig. 145 shows the two portions of the coupling shut together, covered by the vulcanized india-rubber casing with which each is provided.

259. The "battery and bell-box" for the guards' van is

FIG. 145.

that already described, but with the wires brought up to two couplings similar to that used for connecting the several sections of the line wire.

The rope is threaded through the carriage-door handles, and the alarm is sounded by pulling it, in the same manner as one would the ordinary mechanical rope communication. The strain thus placed upon it brings the two wires into connection at the nearest coupling, and thereby sets the bells ringing. Should the train break away, one or more of these couplings would be drawn asunder, and the contact points, being no longer separated by the fangs of the fellow coupling, would close upon each other and complete the connection between the two wires. This takes place in both directions, and

hence the bells in the vans, or on the engine in front, and of the brake in the rear, are set in motion and continue to ring until the fracture is made good, or the rope is disconnected from the battery box.

Walker's System.

260. It has been stated that the main principle upon which Walker's and Preece's systems are based is identical. This is so, so long as the train comprises but two brake-vans; but on the introduction of a third van this similarity disappears. It will have been seen that in Preece's system any number of vans may be added to the train without involving any change whatever in the apparatus, or in the make-up of the train. This is not the case with Walker's. His battery power is utilized from the vans at either end of the train, and thus the introduction of a third van involves the adjustment of a switch, which is manipulated or arranged according to the position occupied by the van. Aside from the slight complication which this introduces, there is, however, no demerit in its application. Its object is, as will have been gathered, to switch the battery out of circuit, or to reverse its poles as may be required. A coach fitted with Preece's system would work perfectly well if coupled up with one of Walker's vans; and a coach fitted with Walker's would work equally well if attached to a van fitted with Preece's system.

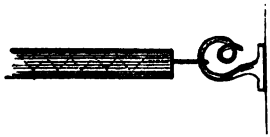


FIG. 145.

261. The details of the two systems, however, differ. In Walker's the connections between the coaches consist of brass spiral springs covered by

india-rubber tubing, having a loop at each end, which, when the train is coupled up, are placed over a plain compound hook, Fig. 146; a good continuity being secured between the hook and the coupling by means of the spiral construction of the latter. A plain piece of wire, on emergency, answers the same purpose as the spiral coupling, provided it is firmly twisted round the hook where it has been made bright and clean by the friction of the spiral link. These couplings are removed when the train is broken up. There is no duplicate arrangement as in Preece's, the sole connection being made about the centre of each end of the vehicle.

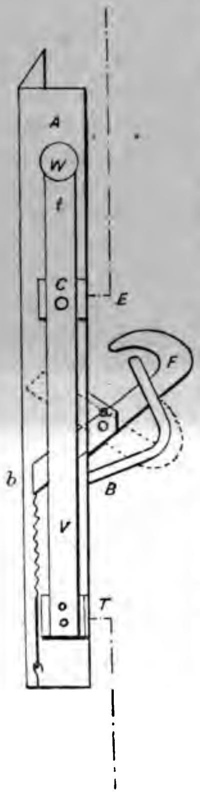


FIG. 147.

262. Fig. 147 represents the **break-away arrangement** employed where such is required. B is a fixed, or stop-hook. F is another hook free to move on its centre *a*, but which is forced down to the dotted position when a strain is placed upon it by the connecting spiral previously referred to. C is a flat vertical spring, at the top of which is a weight W. E is a metal plate connected to the wheels or earth-wire; and at the point C are two contact points, one on the spring and one on the plate E. The line wire is connected at the point marked T.

Behind the point marked V is an inclined plane, so arranged that when the hook F is pulled down by the tension of the connecting spirals the end *b* will ride up it, and thus separate the contacts C and E; the result of which is, that so long as the hook F is held down in the dotted position, the line wire and the earth connection will be separated, but when the tension is removed by the train breaking away, the inclined plane forces F back into its normal position, and the contact between the line and earth is then effected.

The object of the weight W is to keep up, assisted by

FIG. 148.

the motion of the train, an oscillation of the spring C, by which means the connection between it and E will be made and broken, and corresponding intermediate rings will be given on the bells.

263. Fig. 148 is a view of the **commutator** which is fixed in the carriage, within reach of the passenger, for raising the alarm. It is not placed, as in Preece's, in the centre of the compartment, but over the window on one side of the carriage. Every closed compartment thus requires one commutator. It is unprotected by any covering, and is brought into action by pulling out the small knob in its centre, as shown in the figure.

On withdrawing it from its position of rest, the line wire is brought into circuit with the earth wire, and the bells set ringing. At the same time a small indicator *a*, Fig. 149 (usually made of wood painted white and red) attached to a spring *b*, the tendency of which is to thrust the disc out at right angles from the line of carriages, is released. The commutator handle cannot be restored to its place, nor the disc laid alongside the carriage, without the aid of a key, carried by the guard for that purpose.

264. The **bell and battery arrangement** is similar to that referred to under Preece's system, except that the bell is a single-stroke bell.

265. The **engine signal** is worked from the front

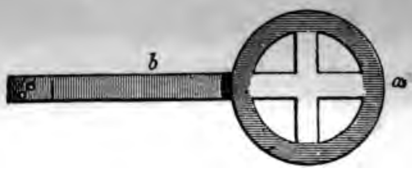


FIG. 149.

van only. It consists of a bell and an indicator in the shape of a semaphore signal, which when placed at danger requires the driver to stop.

266. **The question whether the engine signal should be in circuit with the entire train or only worked from the front van** has frequently been discussed, and so far the tendency has been to confine it to the latter; but in view of the adoption of continuous brakes under the control of the engine-driver, it would seem desirable to adopt the former arrangement. Again, it has been thought that an alarm, sounded or signalled to the engine-driver on the electrical apparatus *may be* sufficiently answered by sounding the engine-

whistle. It is open to question if this course is so desirable as may at first sight appear to be the case. It is certain that the guard's attention may be as, if not more, readily obtained by a response on the bell placed in his van, as by the whistle. The advantage would therefore appear to be on the side of giving the driver the same means of claiming the attention of the guard as the guard has of claiming that of the driver.

On Red Paper.]

A. AND B. RAILWAY.

_______________ *Section.*

Order for Train NOT to proceed on Journey.

Prefix.	Code Time.	No. of Words.	Station to which the Message is forwarded.	Time Forwarded. Fin.	Forwarding Clerk's Signature.
S P R				h. m. ,, — m.	

_______________ *Station* _______________ 187

FORWARD the following S P R Message—

From _______________ *To* _______________

_______________ *Station* _______________ *Station*

____

____

____

____

Signed _______________ *Agent.*

Repetition correct.

_______________ Tel. Clerk.

On White Paper.]

A. AND B. RAILWAY.

____________________*Section.*

Order for Train NOT to proceed on Journey.

Prefix.	Code Time.	No. of Words.	Station to which the Message is forwarded.	Time forwarded. Fin.	Forwarding Clerk's Signature.
S P R				h. m. ,, — m.	

________________*Station*________________ 187

FORWARD the following S P R Message—

*From*________________ *To*________________

________________*Station* ________________*Station*

*Signed*________________*Agent.*

Repetition correct.

________________*Tel. Clerk.*

On Red Paper.]

A. AND B. RAILWAY.

________________ *Section.*

Order for Train NOT to proceed on Journey.

(For Agent's use.)

Prefix.	Code Time.	No. of Words.	Station from which the Message is received.	Receipt. Fin.	Receiving Clerk's Signature.
SPR				h. m. " — m.	

________________ *Station* ________________ 187

From ________________ *To* ________________

________________ *Station* ________________ *Station*

Signed ________________ *Agent.*

Repetition correct.

________________ *Tel. Clerk.*

A. AND B. RAILWAY.

Special Order to Engineman and Guard NOT to proceed on Journey.

The { ______ Up Train / ______ Down Train } is not to pass ______

Station, till { ______ Up Train / ______ Down Train } has arrived at ______

SEE TELEGRAPH ORDER AT BACK.

Date ______

Time ______

Signed ______ *Agent.*

______ *Station.*

On White Paper.]

A. AND B. RAILWAY.

______________ *Section.*

Order for Train NOT to proceed on Journey.

(Office Copy.)

Prefix.	Code Time.	No. of Words.	Station from which the Message is received.	Receipt. Fin.	Receiving Clerk's Signature.
SPR				h. m. —" m.	

______________ *Station* ______________ 187

From ______________ *To* ______________

______________ *Station* ______________ *Station*

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Signed ______________ *Agent.*

Repetition correct.

______________ Tel. Clerk.

On Red Paper.]

A. AND B. RAILWAY.

______________________ *Section.*

Order for Train NOT to proceed on Journey.

AGENT'S REPLY.

Prefix **S P R** Code Time________ No. of Words

Station to which the Message is forwarded.	Time forwarded. Fin.	Forwarding Clerk's Signature.	Station from which the Message is received.	Time received. Fin.	Receiving Clerk's Signature.
	h. m. ,, — m.			h. m. ,, — m.	

______________ ______ *Station* ________________ 187

From ________________ } *To* ________________

________________ *Station* } ________________ *Station*

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Signed ____________ *Agent.*

Correct.

________________ *Tel. Clerk.*

NOTE.—This form is available for use by the forwarding as well as the receiving station.

On White Paper.]

A. AND B. RAILWAY.

____________________ *Section.*

Order for Train NOT to proceed on Journey.

AGENT'S REPLY.

(Office Copy.)

Prefix **S P R** Code Time________No. of Words________

Station to which the Message is forwarded.	Time forwarded. Fin.	Forwarding Clerk's Signature.	Station from which the Message is received.	Time received. Fin.	Receiving Clerk's Signature.
	h. m. ,, — m.			h. m. ,, — m.	

________________ *Station* ________________187

From ________________ *To* ________________

________________ *Station* ________________ *Station*

Signed ________________ *Agent.*

Correct.

________________ *Tel. Clerk.*

NOTE.—This form is available for use by the forwarding as well as the receiving station.

On Green Paper.]

A. AND B. RAILWAY.

______________________ *Section.*

Order for Train TO PROCEED on Journey.

Prefix.	Code Time.	No. of Words.	Station to which the Message is forwarded.	Time Forwarded. Fin.	Forwarding Clerk's Signature.
S P G				h. m. ,, — m.	

______________________ *Station* ______________ 187

FORWARD the following S P G Message.

From ______________________ } *To* ______________________

______________ *Station* } ______________ *Station.*

____

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Signed ______________ *Agent.*

Repetition correct.

______________ Tel. Clerk.

On White Paper.]

A. AND B. RAILWAY.

______________________ *Section.*

Order for Train TO PROCEED on Journey.

Prefix.	Code Time.	No. of Words.	Station to which the Message is forwarded.	Time Forwarded. Fin.	Forwarding Clerk's Signature.
S P G				h. m. — " m.	

______________________ *Station* ______________ 187

FORWARD the following S P G Message—

From ______________________ } *To* ______________________

______________________ *Station* } ______________________ *Station*

____

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____

Signed ______________________ *Agent.*

Repetition correct.

______________________ *Tel. Clerk.*

On Green Paper].

A. AND B. RAILWAY.

______________________ *Section.*

Order for Train TO PROCEED on Journey.

(For Agent's use.)

Prefix.	Code Time.	No. of Words.	Station from which the Message is received.	Receipt. Fin.	Receiving Clerk's Signature.
SPG				h. m. — ,, m.	

______________________ *Station* ______________________ 187

From ______________________ *To* ______________________

______________________ *Station* ______________________ *Station*

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Signed ______________________ *Agent.*

Repetition correct.

______________________ Tel. Clerk.

On Green Paper].

A. AND B. RAILWAY.

______________ *Section.*

Order for Train TO PROCEED on Journey.

(For Agent's use.)

Prefix.	Code Time.	No. of Words.	Station from which the Message is received.	Receipt. Fin.	Receiving Clerk's Signature.
S P G				h. m. ,, — m.	

______________ *Station* ______________ 187

From ______________ *To* ______________

______________ *Station* ______________ *Station*

____

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____

____

Signed ______________ *Agent.*

Repetition correct.

______________ Tel. Clerk.

U

A. AND B. RAILWAY.

Special Order to Engineman and Guard TO PROCEED on Journey.

The { ____________ Up Train / ____________ Down Train } is to go on to ____________

Station, and there pass the { ____________ Up Train. / ____________ Down Train.

SEE TELEGRAPH ORDER AT BACK.

Date ____________

Time ____________

Signed, ____________ *Agent.*

____________ *Station.*

On White Paper.]

A. AND B. RAILWAY.

______________ *Section.*

Order for Train TO PROCEED on Journey.

(Office Copy.)

Prefix.	Code Time.	No. of Words.	Station from which the Message is received.	Receipt. Fin.	Receiving Clerk's Signature.
SPG				h. m. — ,, m.	

______________ *Station* ______________ 187

From ______________ *To* ______________

______________ *Station* ______________ *Station*

____

____

____

____

Signed ______________ *Agent.*

Repetition correct.

______________ Tel. Clerk

U 2

On Green Paper.]

A. AND B. RAILWAY.

______________________________ *Section.*

Order for Train TO PROCEED on Journey.

AGENT'S REPLY.

Prefix **SPG** Code Time No. of Words ______

Station to which the Message is forwarded.	Time forwarded. Fin.	Forwarding Clerk's Signature.	Station from which the Message is received.	Time received. Fin.	Receiving Clerk's Signature.
	h. m. ,, —m.			h. m. ,, —m.	

______________________ *Station* ______________________ 187

From ______________________ *To* ______________________

______________________ *Station.* ______________________ *Station.*

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Signed *Agent.*

Correct.

______________________ *Tel. Clerk.*

NOTE.—This form is available for use by the forwarding as well as the receiving Station.

On White Paper.]

A. AND B. RAILWAY.

_______________ *Section.*

Order for Train TO PROCEED on Journey.

AGENT'S REPLY.

Prefix **SPG** Code Time ______ No. of Words ______

Station to which the Message is forwarded.	Time forwarded. Fin.	Forwarding Clerk's Signature.	Station from which the Message is received.	Time received. Fin.	Receiving Clerk's Signature.
	h. m. ,, —m.			h. m. ,, —m.	

______________ Station ______________ 187

From ______________ *To* ______________

______________ *Station* ______________ *Station*

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Signed ______________ *Agent.*

Correct.

______________ *Tel. Clerk.*

NOTE.—This form is available for use by the forwarding as well as the receiving Station.

NOTE.—The following form is used supplementary to the recognized Train Staff Rules.

Midland Great Western Railway.

No. ____________

Prefix—**T.R.** Code Time ______ No. of Words ____	Date ______ 187	Handed in at ____ Sent to ________ Sent at ________ Sent by ________

From ______________ Station to ______________ ation.

Has the ________________________ Train No. _____

(________) arrived at ____________________ Station ?

Is the Line clear for the

____ Train

to proceed to ______________________ Station ?

Signature, ______________________

Station Master.

(ANSWER.)

Prefix—**T.R.**	Date_____ 187	Recd. from_____
Code Time_____		Recd. at_____
No. of Words___		Recd. by_____
		Sent out at_____

From_____________ Station to_____________ Station.

(________) The_________________Train No.______

has arrived at______________________Station.

The line is clear for the

____ Train

to proceed to_____________________Station.

Signature,___________________________

Station Master.

*** To be used for **TRAINS DEPARTING** from this Station.

*** This Answer is to be repeated, and copied by the Telegraph Clerk upon the accompanying " Line Clear " form, and the Ticket is then to be separated by him from the block, and given to the Station Master.

N. B.—Every word is to be signalled whether printed or written, *but* the written words only are to be counted.

NOTE.—This form is used supplementary to the recognized Train Staff Rules.

Midland Great Western Railway.

No.______ LINE CLEAR TICKET. (TELEGRAM.)

Prefix—**T.R.**		Rec^d. from______
Code Time______	Date _____ 187	Rec^d. at______
		Rec^d. by______
No. of Words____		Sent out at______

From______________Station to____________Station.

(________) The________________Train No.______

has arrived at__________________Station.

The line is clear for the

____Train

to proceed to____________________Station.

Signature,____________________

You are authorized (*if you have the Train Staff for the Section with you; or should you carry a Train Ticket after seeing the Train Staff for the Section*),

to proceed from__________________________Station

to______________________Station, the LINE having

been telegraphed "CLEAR," by above Message.

Signature,____________________

Station Master.

*** This "Line Clear" Ticket is to be handed by the Station Master along with the Train Staff or Train Ticket to the Guard, and by the Guard to the Engine Driver at the departure Station, as his authority to start.

*** This Ticket is to be handed by the Engine Driver to the Guard, and by the Guard given up to the Station Master, *immediately on* reaching the arrival Station.

N.B.—This Ticket is to be CANCELLED by the Station Master at the arrival Station when it reaches him.

NOTE.—This form is used supplementary to the recognized Train Staff Rules.

Midland Great Western Railway.

No.______

Prefix—**T.R.**
Code Time______ } Date______187 { Rec[d]. from______
No. of Words____ } { Rec[d]. at______
{ Rec[d]. by______

From______________Station to______________Station.

Has the______________________________Train No.______

arrived at______________________________Station?

Is the Line clear for the

____Train

to proceed to______________________________Station?

Signature,______________________________

Station Master.

(ANSWER.)

Prefix—**T.R.**
Code Time______ } Date______187 { Handed in at______
No. of Words____ } { Sent at______
{ Sent to______
{ Sent by______

From______________Station to______________Station.

The______________________________Train No.______

has arrived at______________________________Station.

The Line is clear for the

____Train

to proceed to______________________________Station.

Signature,______________________________

Station Master.

*** To be used for **TRAINS ARRIVING** at this Station.

NOTE.—This form is used supplementary to the recognized Train Staff Rules.

Midland Great Western Railway.

No.______

Prefix—**T.A.**
Code Time______ Date____ 187 Recd. at________
No. of Words____ Recd. from______
Recd. by_______

From ______________ To ______________

The ________________________ Train

left at ____________________ o'Clock.

Signature, ________________________

(ANSWER.)

Prefix—**T.A.** Sent at________
Code Time______ Date______ 187 Sent to________
No. of Words____ Sent by________

From ______________ To ______________

The ________________________ Train

arrived at ____________________ o'Clock.

Signature, ________________________

*** To be used for **TRAINS ARRIVING** at this Station.

B Signal Box. A. & B. R. Train Signal

______day, the______of______187

DOWN TRAINS.	Description of Train.	Line Blocked, from	Departure Signal Received from	Line Blocked at	Train Arrived or Passed from	Line Blocked at	Train Left or Departed to	Departure Signal sent to	Line Blocked from	Line Clear to	Line Cleared from	Line Clear from	Line Cleared to
		Box A.				Box C.				Box A.		Box C.	
1													
2													
3													
4	(Example.)												
5													
6	8 a.m. pass.	8.20	8.21	8.21	8.25	8.35	8.37	8.37	8.37	8.37	8.37	8.42	8.42
7													
8													
9													
10													
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													
21													

REMARKS AS TO DOWN TRAINS (*Refer to above by Numbers*).

Book for Single Lines. ______ Signal Box.

______day, the______of 187

UP TRAINS.	Description of Train.	Line Blocked from	Departure Signal Received from	Line Blocked at	Train Arrived or Passed from	Line Blocked at	Train Passed or Departed to	Departure Signal sent to	Line Blocked from	Line Clear to	Line Cleared from	Line Clear from	Line Cleared to
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
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14													
15													
16													
17													
18													
19													
20													
21													

REMARKS AS TO UP TRAINS (*Refer to above by Numbers*).

ignal Box B. A. & B. R. Junction Train

_______ day, the _______ of _______ 187

TRAINS.	Description of Train. Up.	Box C. Departure Signal Received from	Box C. Line Blocked at	Box C. Train Arrived or Passed from	Box C. Line Cleared back to	Box D. Departure Signal Received from	Box D. Line Blocked at	Box D. Train Arrived or Passed from	Box D. Line Cleared back to	Box A. Train Passed or Departed to	Box A. Departure Signal sent to	Box A. Line Blocked from	Box A. Line Cleared back from
1													
2													
3													
4													
5	(Example.)												
6													
7	8.0 main.	8.30	8.30	8.32	8.32					8.32	8.32	8.32	8.35
8													
9													
10													
11													
12	10.0 branch.					10.15	10.15	10.17	10.17	10.17	10.17	10.17	10.20
13													
14													
15													
16													
17													
18													
19													
20													
21													

REMARKS AS TO TRAINS (*Refer to them by Number*).

Signal Book for Double Lines. ——— Signal Box.

———day, the———of 187

TRAINS.	Description of Train.	Departure Signal Received from	Line Blocked at	Train Arrived or Passed from	Line Cleared back to	Train Passed or Departed to	Departure Signal sent to	Line Blocked from	Line Cleared back from	Train Passed or Departed to	Departure Signal sent to	Line Blocked from	Line Cleared back from
1													
2													
3													
4													
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16													
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18													
19													
20													
21													

REMARKS AS TO TRAINS (*Refer to them by* Number).

X

B Signal Box. A. & B. R. Train Signal.

________day, the________of________187

DOWN TRAINS.	Description of Train.	Departure Signal Received from	Line Blocked at	Train Arrived or Passed from	Line Cleared back to	Train Passed or Departed to	Departure Signal sent to	Line Blocked from	Line Cleared from
		Box A.				Box C.			
1									
2									
3									
4									
5	9.30 Goods	10.0	10.0	10,5	10.6	10.5	10.5	10,5	10,12
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									

REMARKS AS TO DOWN TRAINS (*Refer to above by Numbers*).

Book for Double Lines. ______Signal Box.

______day, the______of______187

UP TRAINS.	Description of Train.	Departure Signal Received from	Line Blocked at	Train Arrived or Passed from	Line Cleared back to	Train Passed or Departed to	Departure Signal sent to	Line Blocked from	Line Cleared from
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									

REMARKS AS TO UP TRAINS (*Refer to above by Numbers*).

INDEX.

INDEX.

INDEX.